Non-linear commodity taxation in developing countries: theory and an application to India

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Abstract

Many developing countries simultaneously tax commodities and subsidize them up to a quota level through ration shops. This particular combination of taxes and subsidies plays an important role in the public budgets of developing countries; India spends 1 GDP point on its ration shop system and levies more than 60% of its revenues through commodity taxes. This paper first studies under what conditions this tax schedule - de facto convex commodity taxes - is welfare improving compared to standard linear taxes once we take into account the relevant characteristics of developing countries. These are i) limited government capacity to observe household incomes and ii) market fragmentation. I find that an inequality-averse government would set convex taxes on a wide range of goods to redistribute and to partially insure households against price risk. Welfare gains to introducing convex taxes are highest for normal goods that most poor households consume. I then take the model to Indian data and find that combining ration shops and commodity taxes is welfare improving for rice, wheat and kerosene, but not for sugar. Setting convex taxes on other goods not currently in the Indian ration shop system would not help the government redistribute across households but would yield small insurance gains.

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1 Introduction

Developing countries use a particular combination of commodity taxes and subsidies through ration shops which is has long been abandoned in rich countries. Ration shop systems grant each household a right to purchase quotas of goods at a fixed subsidized price, consumption above the quota is subject to commodity taxes. These taxes and subsidies represent a large share of these countries' public budgets: in India, ration shops costs over 1% of GDP whilst commodity taxes raise over 60% of revenues (GoI, 2012).

This form of commodity taxation in which the tax rates are increasing in the amounts consumed is typically considered by the literature as unfeasible because governments do not observe consumption levels.[1] Moreover, redistribution through commodity taxes is known to be inefficient when income taxes are available under fairly general assumption since Atkinson and Stiglitz (1976), making non-linear differentiated commodity taxes a priori undesirable in the types of models routinely used by the literature.

Given their widespread use in developing countries this paper takes the feasibility of a constrained form of non-linear commodity taxes as a starting point. I study under which conditions such taxes are welfare improving compared to linear commodity taxes because these countries differ from rich countries in two important ways. First, many developing countries have limited state capacity and in particular limited capacity to observe individual incomes (Besley and Persson, 2013, 2014). Income tax and transfers are therefore costly to implement, introducing the possibility that differentiated commodity taxes may be part of the optimal tax mix (*redistribution* motive). Second, high transport costs, under-developed retail markets and trade regulations across different regions lead to poor spatial market integration in developing countries. Retail prices consequently co-vary strongly with local supply shocks and there are substantial price variations both across regions and over time. This implies that governments that cannot monitor local prices may wish to redistribute in-kind even when income taxes and transfers are available (*social insurance* motive).

This paper's first contribution is a model of piecewise convex commodity taxation which takes into account the characteristics of developing countries and studies i) under what conditions these characteristics imply that ration shop schedules are welfare improving compared to linear taxes, ii) for which types of goods the welfare gains from ration shop schedules are large and iii) the optimal form of the ration shop schedule. I set up a Ramsey-type model of commodity taxation in which households differ in their consumption preferences and incomes and face an exogenous price risk; I allow for the possibility that households consume from their own production to capture the fact that in developing countries some rural households

[1] This characteristic of commodity taxation is seen by Atkinson and Stiglitz (1980) as the main difference between direct and indirect taxes "...the essential aspect of the distinction [is] the fact that direct taxes may be adjusted to the individual characteristics of the taxpayer, whereas indirect taxes are levied on transactions irrespective of the circumstance of buyer and seller." (Atkinson and Stiglitz (1980), p 427)

are net producers of agricultural goods.

I obtain general conditions under which a piecewise convex tax system is welfare improving. There is a trade-off between efficiency and equity: a revenue-maximizing government will not choose to use a ration shop schedule because it would implement higher marginal prices for households with the highest demand for the good, lowering overall demand compared to linear taxes.[2] When governments place a positive weight on households' utility, ration shop schedules can be welfare-improving for most types of goods. The highest welfare gains from introducing these schedules are obtained for normal goods - so that taxing higher levels of consumption more affects the rich disproportionately - that are still widely consumed by the poor, so that most of them are affected by the lower prices on low consumption levels. Market fragmentation leads to price risk which increases the insurance gains from ration shops, but this effect is smaller when poorer households produce the good at home.

This paper's second contribution lies in its application of the model to India. India's ration shop system is large: it subsidizes more than 15% of the total purchases of rice, wheat, kerosene and sugar in the country and is used by nearly three quarters of households.[3] I simulate numerically the marginal redistribution and insurance benefits of introducing a ration shop schedule for seven good categories using the consumption module of the 2011-2012 Indian household survey. This survey documents household consumption from ration shops, markets and home production and therefore allows me to simulate the joint distributions of incomes and consumption patterns under different counterfactual tax scenarios. It is available annually; I use past editions of the survey to compute a measure of price variation over time at the district level.

I find that introducing rations shops is welfare improving compared to linear taxes or subsidies for most specifications of household and government preferences for three goods that are currently distributed through the ration shop system - kerosene, wheat and rice. The consumption profile of these three commodities approximate the ideal scenario outlined by the model - normal goods that are widely consumed by poorer households. Sugar is also distributed through the ration shop system, my model predicts that this is not optimal for even very small fixed implementation costs: the gains to taxing sugar non-linearly are small or negatuve because sugar is a commodity that richer households consume substantially more of and whose price varies little over time. I consider three other types of commodities (pulses, coarse cereals and meat and fish) and find no redistribution gains from introducing them in the ration shop system. The prices of meat and fish vary over time roughly as much as that of kerosene and there are insurance benefits from including these goods in ration shops.

The model departs from the traditional public finance literature in two main directions

[2]This result is reminiscent of the price quantity discount in Maskin and Riley (1984).

[3]See Tarozzi (2005), Khera (2011), Sukhtankar and Niehaus (2011), Khera and Dreze (2013), Himanshu (2013), Kaul (2014), Nagavarapu and Sekhri (2014) for recent studies of the Indian ration shop system.

which are motivated by the context of developing countries and well documented in the development literature. First, optimal tax theory typically assumes that whilst ability and effort are unobservable income can be taxed by the government but I assume that income itself is not observable.[4] This assumption captures the idea that governments in developing countries have limited capacity to monitor transactions and enforce taxes at the individual or household level (see for example Keen (2012), Besley and Persson (2014)) and so levy very little income taxes, preferring to rely on sales taxes to raise revenue (Gordon and Li, 2009), and rarely implement direct means-testing. The second departure is motivated by the specific market environment of developing countries: the existence of many imperfectly integrated spatial markets for commodities, as documented in the trade literature(Fackler and Goodwin, 2001, Atkin, 2013, Atkin and Donaldson, 2014).

A large literature in development has studied how governments redistribute without observing income (Coady *et al.*, 2004, Alatas *et al.*, 2012). This literature has mostly considered commodity subsidies through the lens of the cash versus kind debate, focusing on justifications for in-kind redistribution that stem from general equilibrium effects (pecuniary redistribution - see Coate *et al.* (1994)) or market forces (incidence - see Cunha *et al.* (2011)).[5] I first abstract from this debate to show how convex commodity taxes can be used to redistribute even in the absence of these effects. I then introduce price risk, and show under which conditions this justifies the introduction of in-kind transfers as part of a ration shop schedule.

This paper contributes to the growing literature on public finance in developing countries.[6] I show that under some conditions a form of taxation that has largely been ignored by the literature is a useful policy instrument in the context of developing countries in which the set of tax instruments is both more constrained than in developed countries (absence of income taxes) and simultaneously more general (use of piecewise commodity taxes). This approach is closely related to that followed by Best *et al.* (2013) who show that turnover taxes may be part of the optimal tax mix in developing countries because of the particular constraints faced by governments in this context - in their case, high levels of tax evasion (see also Emran and Stiglitz (2005), Boadway and Sato (2009), Dharmapala *et al.* (2011) for theoretical work on the topic).[7]

To the best of my knowledge this paper is the first to consider both the possibility and the shape of convex commodity taxes. A small literature in public finance has considered non-

[4]This assumption can be relaxed. The model extends naturally to the case where the government can observe income but at a cost.

[5]An important exception is Besley and Kanbur (1988) who discuss how commodity subsidies can best be used to maximize targeting and minimize leakage, and point out that the widespread use of quota systems may well be efficient. They focus on the case with full resale.

[6]See for example de Paula and Scheinkman (2010), Olken and Singhal (2011), Kleven and Waseem (2013), Kumler *et al.* (2013), Pomeranz (2013), Carpio (2014), Carrillo *et al.* (2014), Cagé and Gadenne (2014), Gadenne (2014), Gerard and Gonzaga (2014), Khan *et al.* (2014).

[7]See also Ashraf *et al.* (2012), Niehaus and Sukhtankar (2012), , Niehaus *et al.* (2013), Muralidharan *et al.* (2014) for recent work on public finance in developing countries not directly related to taxation.

linear taxation of specific goods for which the assumption that consumption levels are known to the government may hold in practice, for example housing (Cremer and Gahvari, 1998) or education (Bovenberg and Jacobs, 2005).[8] This literature assumes the existence of 'indicator goods', as defined by Nichols and Zeckhauser (1982)and hence opens up the possibility that non-linear commodity taxes on those goods relax the self-selection constraint faced by the optimal income tax problem. This paper departs from this literature by studying when non-linear commodity taxes are optimal even in the absence of indicator goods when income taxes are not available.[9] The model's assumptions are in the spirit of Ramsey (1927) (exogenous, non taxable income), Diamond (1975) (heterogenous preferences) and Varian (1980) (exogenous price risk). The introduction of non-linear taxes also relates the model to the Mirrleesian optimal income tax tradition. Methodologically, my emphasis on deriving formulas expressed as a function of parameters that can be estimated from standard datasets is similar to Saez (2001), and my focus on the practically relevant piecewise tax schedule mirrors that in Apps *et al.* (2013) who study optimal piecewise income taxes.[10]

The paper is organized as follows. Section 2 describes the system of non-linear commodity taxes and subsidies in developing countries, focusing on the Indian example. Section 3 considers the constrained piecewise commodity tax problem and derives conditions under which a ration shop schedule is welfare improving and expressions for the optimal schedule. Section 4 explains the methodology and data used to implement these expressions numerically for India. Section 5 presents and discusses the results.

2 Context: non-linear commodity taxes in developing countries

This section first gives a brief overview of commodity taxes and subsidies in developing countries. I then provide more detail on the Indian example which I later apply the model to, focusing on four stylized facts which are building-blocks of the model developed in section 3.

2.1 Commodity taxes and ration shops in developing countries

Many developing countries use a form of ration shops today and most have experimented with some version of subsidized quotas of basic necessities throughout their history. Table 1

[8] See Currie and Gahvari (2008) for a review.

[9] Another related paper by Sah (1983) shows that redistribution through commodity taxes is limited by the extent to which budget shares are differentiated along the income distribution. He argues that differences in consumption are too small for much redistribution to be obtained through commodity taxes, and suggests that this is a problem in developing countries which rely heavily on those types of taxes. This paper points out that this result no longer holds once we take into account the fact that developing countries are in practice taxing commodities non-linearly.

[10] See also Sheshinski (1989), Slemrod *et al.* (1994).

presents a non-exhaustive list of countries in which ration shop systems exist, restricted to examples for which estimates of the cost of the program are available. Commodity subsidies are typically universal, large, and limited to food staples and fuel. Implementation forms vary: some countries opt for food stamps which can be redeemed in most retail outlets (Sri Lanka) but most countries rely on a network of ration-shops which only sell goods at a fixed subsidized price and are responsible for implementing the quota amounts. The history and current functioning of these ration systems is well documented in Alderman (2002), Rogers and Coates (2002), Kennedy and Harold (1987). These commodities subsidies are financed through public revenues, the bulk of which comes from commodity taxes. Gordon and Li (2009) estimate that over half of public revenues in developing countries come from taxes on consumption.

2.2 The Indian example

India's ration shop system is known as the Public Distribution System and was created in 1939. The general principle is the following: eligible households are entitled to purchase a given quota amount $\bar{c}$ of four commodities - rice, wheat, kerosene and sugar - at a fixed subsidized price p. Consumption above the quota must be purchased on the market and market purchases may be taxed.[11] Commodity tax revenues constitute 66% of total public revenues. A large share of these revenues (6%, or 1% of GDP) goes towards funding the ration shop system. Whilst the funding comes primarily from the federal government the system is implemented by India's 29 state governments which determine (under some constraints) the eligibility criteria, ration prices, quota amounts and tax rates. Each household is given a ration card and can purchase its quotas in the country's more than 450,000 ration shops. Access is high: 70% of Indian households report using the ration shop system over the last month in India's latest consumption survey.[12] Table 2 presents descriptive statistics for the four goods distributed through the system. A large share of total consumption - above 15% for each good, up to 72% for kerosene - goes through the ration shop system. Quota amounts vary by state but are typically large - close to average total household consumption for each good. The subsidy is substantial: ration prices are 25 to 50% lower than market prices.

A first question of interest is whether the ration shop system targets the poor. Roughly half of Indian states implement de-jure targeting: they specify that only households identified as poor are eligible to use the ration shop system. Each state uses its own criteria to identify poor households, using a combination of proxies measured through occasional state-level surveys and ad hoc decisions by local governments. In other states all households have access to the

[11] Rice wheat and sugar are currently tax-exempt under the current Indian VAT system but were taxed at a positive rate in some states until 2005. The average tax is on kerosene is 12.5%.

[12] All the statistics in this section were computed by the author using the NSS 2011-2012 consumption survey, unless otherwise specified. The dataset is described in Setion 4.

ration shop systems.[13] There could however be de facto targeting in those states if non-poor households choose to self-select out of the system: there is anecdotal evidence that households must queue to purchase their ration shops, introducing an ordeal element to the system, and that the quality of goods sold in the ration shops is sometimes mediocre (Rao, 2000). If the opportunity cost of time or taste for quality increase with income we expect to see the non-poor self-select out of using the ration shop system, regardless of whether or not eligibility is restricted. Whilst there is an income gradient to usage of the ration shop system, Figure 1 shows that it is weak. I compare the distribution of household consumption (all goods considered) from the ration shops by real poverty status in states that explicitly target the ration shop system to the poor and those that do not.[14] Overall 60-70% of non-poor households and 80-85% of the poor report using the ration shops. These numbers are extremely similar in states in which all households are eligible to a ration card and states in which only poor households are eligible. The figure suggests two reasons for the small difference in ration shop usage by the poor and non-poor. First, Indian states have a very poor capacity to measure income.[15] Second, whilst there may be an ordeal element to the ration shop system it is insufficient to deter most of the non-poor from using the system. This leads to a first stylized fact regarding targeting which I will take to the model:

Stylized Fact 1 *Poor targeting: the ration shop system does not target the poor much, both because of poor government capacity to identify poor households and a limited self-targeting component.*

The second stylized fact regards the implementation of the system. There is evidence of high corruption and administrative costs are plenty[16], and a comprehensive estimate of cost leakages -regardless of their source - is that 36% of the subsidies never reach households (Planning Commission, 2005). Of interest here is whether households face the tax and subsidies the law says they should be facing. In a large survey of households in nine states Khera (2011) finds that over 80% of households report being able to access their full quota amounts at the state-specified ration price in all but the two states of Bihar and Jharkhand in which the ration shop system is notoriously dysfunctional. Parameters of the ration shop system are therefore respected on average. The system's capacity to provide insurance, a key component of the model developed below, would however be seriously impaired if ration shop keepers adjusted ration prices and amounts when prices are high and there is more to gain from selling on the black market. Figure 2 suggests this does not typically happen. I plots the relationship between

[13]The quota amounts and ration prices vary by poverty status in some of these states.

[14]I apply the official state-by-state Tendulkar poverty lines to expenditure per capita to define poverty status.

[15]This is in line with the evidence in Niehaus and Sukhtankar (2013) who compare state-allocated poverty status with actual poverty status in a sample from the state of Karnataka and find that nearly half (48%) of households are misclassified.

[16]See for example Khera and D (2011), Nagavarapu and Sekhri (2014).

median ration price and ration purchases, as reported by households, and median market price for rice in two Indian states that represent the two extreme implementation scenarios in India. In Tamil Nadu the ration shop system is well-implemented, large and efficient relative to other Indian states. Bihar is the state with worse household satisfaction with the system and the highest estimated leakages. In both states we see that ration prices take few values, suggesting ration shop keepers are implementing state parameters (in Tamil Nadu official ration prices vary with location) and are not correlated with market prices. There is a negative correlation between reported consumption amounts from ration shops and market prices, suggesting there may be slightly more diversion on the black market when market prices increase, but it is very low. The descriptive evidence suggests that the system is reasonably well implemented overall:

Stylized Fact 2 *Implementation: the ration shop parameters are respected on the ground. In particular, corruption does not substantially hinder the system's capacity to provide a given level of goods at a fixed price regardless of market prices.*

A related question is the extent to which households arbitrage: the difference between the ration and market price creates a strong incentive to re-sell quotas on the market. This is particularly important for the model: in a situation with perfect re-sale the ration shop system essentially transfers the same amount to all households and is equivalent to a lump-sum transfer (Besley and Kanbur, 1988). No public resources are allocated to fight this illegal behavior but fieldwork suggests it is socially frowned upon. There is no data available on the extent to which households re-sell their quotas, but information on how much they consume from the ration shops enables me to assess the scale of arbitrage indirectly. Figure 3 presents the density distribution of household consumption of rice, kerosene and sugar from the ration shops in Tamil Nadu.[17] If re-sale were costless we would see that all households would choose to purchase their total quota amount in order to re-sell the amounts they are not consuming on the market. This is far from the case as the subsidy is marginal for 20-40% of households. Whilst there could be resale the evidence suggests it is costly, as a large share of households choose not to re-sell (all of) their rations.

Stylized Fact 3 *No (perfect) arbitrage: households cannot costlessly re-sell their ration amounts at the market price.*

Finally, the last column in Table 1 shows that another feature of developing countries must be taken into account when thinking about optimal commodity taxes and subsidies: rural households often produce the goods that are being taxed at home. We see that 20-25% of total consumption of rice and wheat comes from households' own production of these

[17] I choose to present results for Tamil Nadu because in this state the quota amounts vary little across regions and household types and households are the most likely to be able to access their official quota amount but considering other states and using alternative measures of the de facto quotas faced by households yield very similar results.

cereals on their land. The share of households consuming some rice or wheat from their own production is similar for poor and non-poor households (23%). Figure 4 presents the density distribution of consumption from home production for both cereal types for poor and non-poor households that report positive amounts of home production. The non-poor have slightly higher consumption from home production on average, reflecting the fact that they are more likely to have land on which to grow cereals. The presence of home production introduces the possibility that households may be net producers of some of the goods sold in the ration shop system.

Stylized Fact 4 *Home production: some rural households produce the goods on their own land and can therefore consume from their own production.*

3 The model

3.1 Households

There is a continuum of households indexed by i with exogenous income y^i. The total number of households is normalized to one. There are K consumption goods. Each household purchases quantity c^i_k of good k and is endowed with an amount of land from which it produce a fixed amount q^i_k of each good. I denote by c^i_{mk} the amount that household i choose to consume from its own production of the good, it sells the rest $(q^i_k - c^i_{mk})$ on the market at the exogenous (pre-tax) price z_k. The government cannot tax income or total consumption but taxes the sales of goods. It levies a tax t_{2k} on consumption above a quota $\bar{c}_k$ and sets the price p_k below $\bar{c}_k$ such that households pay p_k on purchases below $\bar{c}_k$ and $z_k + t_{2k}$ on purchases above $\bar{c}_k$.I assume households cannot re-sell their rations on the market, the theory appendix shows that results regarding the conditions under which a ration shop schedule is welfare improving are very similar if I assume households can re-sell their rations at a cost. Before tax prices z_k can take two values with the same probability of 0.5: each household faces price z_{kh} in state $j = h$ and z_{kl} in state $j = l$ where $z_{kh} > z_{kl}$ and $\Delta z_k = z_{kh} - z_{kl}$. The marginal price of the good ρ_k can therefore take three values p_k, $z_{kh} + t_{2k}$, $z_{kl} + t_{2k}$ and the tax schedule is such that $p_k \leq z_{kl} + t_{2k}$, as explained below.

Households maximize utility $U^i(c^i + c^i_m)$ subject to the budget constraint $\sum_k p_k c^i_k D_{kj} + (1 - D_{kj})[p_k \bar{c}_k + (z_k + t_{2k})(c^i_k - \bar{c}_k)] \leq y^i + z_k(q^i_k - c^i_{mk})$, where D_{kj} is equal to one if the household's purchase of good k is below $\bar{c}_k$ in state j, and the home production constraint $c^i_{mk} \leq^i_k$.I write the uncompensated (Marshallian) elasticity of purchases $\epsilon^i_k = \frac{\partial c^i_k}{\partial \rho_k} \frac{\rho_k}{c^i_k}$, the compensated elasticity $\epsilon^i_{kc} = \frac{\partial c^i_k}{\partial \rho_k} \frac{\rho_k}{c^i_k}|_{\bar{U}}$ and the income effect $\eta^i_k = \frac{\partial c^i_k}{\partial R^i} \frac{R^i}{c^i_k}$ where R^i is the virtual income of household i which includes income from home production.[18] The two elasticity concepts are related by

[18] I follow the literature on non-linear income taxation by defining virtual income as the income that the

the Slutsky equation: $\epsilon^i_k = \epsilon^i_{kc} - \eta^i_k s^i_k$ where the compensated elasticity is always non-positive. I write indirect utility as $v^i(\rho, R^i_j, p, t_2, \bar{c}, z_j; c^i, c^i_m)$ where all variables are vectors of length K and relative risk aversion $r_i = -v^{i''}(R^i_j)R^i_j/v^{i'}(R^i_j)$.

I define $\lambda^i(\rho; R^i_j)$ the marginal utility of income at the optimal consumption level of a household in state j facing marginal purchase price ρ and virtual income R^i_j.Taking the derivative of Roy's equality with respect to income we obtain the first derivatives of the marginal utility of income with respect to the marginal price ρ_k :

$$\frac{\partial \lambda^i(\rho; R^i_j)}{\partial \rho_k} = \frac{\lambda^i}{\rho_k} s^i_{jk}(r^i - \eta^i_{jk}) \tag{1}$$

and by definition

$$\frac{\partial \lambda^i}{\partial R^i_j} = -\frac{\lambda^i}{R^i_j} r^i \tag{2}$$

where s^i_{jk} is the budget share of good k in state j.

I assume throughout that $r^i > \eta^i_k$ so that the marginal utility of income is increasing in the marginal price. This is a reasonable assumption if relative risk aversion is higher than 1, as suggested by experimental evidence[19] and goods are not luxury goods, ie η is less than 1. It implies that as the marginal price of a good increases households value extra income more, particularly for goods that represent a large share of their budget. The marginal utility of income is decreasing in income, and more so for more risk averse individuals. I set $\lambda(y^i) = \lambda(R^i_l, \tilde{z} + t)$, the marginal value of income when a household with exogenous income y^i faces the vector of prices $\tilde{z} + t$ where t_k is the optimal linear tax rate on good k as defined below and $\tilde{z} = 0.5(z_h + z_l)$ is the average market price. All other equilibrium values of λ^i can be written as a function of $\lambda(y^i)$ using (1) and (2). I further restrict preference heterogeneity to be a multiplicative term such that $U^{i'}(c^i_k + c^i_{mk}) = \beta^i_k u'(c^i_k + c^i_{mk})$. This allows me to define a parameter θ^i_k which indexes the intensity of each households' demand for the good, $\theta^i_k = \lambda(y_i)/\beta^i_k$. I write the joint density function of home production endowments and preferences $f_k(\theta_k, q_k)$ with support (q_{0k}, q_{mk}) and $(\theta_{0k}, \theta_{mk})$ and omit subscripts k and superscripts i in what follows for clarity.

3.2 Government maximization

The government does not observe households' incomes or the realized pre-tax prices. It chooses the parameters of the tax system $p, t_2, \bar{c}$ where p, t_2 and $\bar{c}$ are vectors of length K to maximize a social welfare function defined as

household would receive if it could stay on the virtual linearized budget: $R^i_j = y^i + (q_i - c^i_m)z_{jk} + \sum_k (1 - D_k)[(z_{jk} + t_{2k} - p_k)\bar{c}_k)]$.

[19] See (Meyer and Meyer, 2005) for a review of the literature on risk aversion and (Carlsson *et al.*, 2003)) for experimental evidence for India.

$$W(p,t_2,\bar{c}) = \int\int_I G(v(p,t_2,\bar{c},z;\theta,q,R))f(\theta,q)d\theta dq \tag{3}$$

where $G(.)$ is continuously differentiable, strictly concave and increasing. I define $g(\theta,q) = \lambda(y(\theta,q))\frac{\partial G}{\partial v}$ the average marginal social welfare weight of a household with preferences θ and endowment q when faced with the price $\tilde{z}+t$, where $y(\theta,q)$ is the income of this household. I assume throughout that $g(\theta,q)$ is a function of household income only: all changes in prices affect marginal social welfare weights only through changes in the marginal value of income.

The government's budget constraint is

$$\begin{aligned}
&\textstyle\sum_k (p_k - \tilde{z})[0.5\int\int_{C_{0h}} c_{pkh}(\theta_k,q_k)f(\theta_k)h(q_k)d\theta_k dq_k + 0.5\int\int_{C0l} c_{pkl}(\theta_k,q_k)f(\theta_k)h(q_k)d\theta_k dq_k \\
&+\textstyle\int\int_{CA}\bar{c}_k f(\theta_k)h(q_k)d\theta_k dq_k] + t_{2k}[\int\int_{C2l} 0.5(c_{kl}(\theta_k,q_k)-\bar{c}_k)f(\theta_k)h(q_k)d\theta_k dq_k \\
&+\textstyle\int\int_{C_{2h}} 0.5(c_{kh}(\theta_k,q_k)-\bar{c}_k)f(\theta_k)h(q_k)d\theta_k dq_k] \le E
\end{aligned} \tag{4}$$

where E is an exogenous revenue requirement, $\tilde{z}$ is average price I_A is the set of households consuming at least $\bar{c}$, $c_{pkj}(\theta,q)$ is equilibrium purchase of households in state j when they purchase less than the quota and $c_{kj}(\theta,q)$ the equilibrium purchase of households in state j when they purchase more than the quota (see discussion below and Appendix).

The two feasibility constraints on the tax schedule are

$$\bar{c} \ge 0 p \le z_l + t_2 \tag{5}$$

The government maximizes $W(p,t_2,\bar{c})$ subject to the budget constraint and these feasibility constraints. The first specifies that the quota level is positive, when it binds the government levies a linear rate t. The second specifies that the tax schedule cannot be concave, $p \le z_l + t_2$: I assume the government cannot force households to pay a higher marginal price for low than for large purchases and so the tax system must implement a convex price schedule.[20] I call any tax schedule $(p,t_2,\bar{c})$ for which the first constraint is non-binding a ration-shop-schedule.

3.3 Results

3.3.1 Equilibrium

For a given tax schedule $p, t_2, \bar{c}$ and state $j = k, l$ there are three solution possibilities to the household's maximization problem which correspond to households with different home production endowments q and preferences for the good θ. These solutions are derived in the Appendix. Households with low preferences for the good and/or high home production endowments purchase less than $\bar{c}$ and face marginal price p. Households with high preferences

[20] For the ration shop to implement a concave price schedule each household would have to show proof of purchase of $\bar{c}$ at the high marginal price in the ration shops before being allowed to purchase on the market, a price system not observed anywhere.

for the good and/or low home production endowments purchase more than $\bar{c}$ and face marginal price $z_j + t$. An intermediate category of households would like to purchase more than $\bar{c}$ at price p but less than $\bar{c}$ at price $z_j + t$, these households purchase exactly $\bar{c}$. Households can therefore be partitioned into three subsets in each state of the world according to their income and home production endowments: households in C_{0j} purchase strictly less than $\bar{c}$, households in C_{1j} purchase exactly $\bar{c}$ and those in C_{2j} purchase strictly more than $\bar{c}$. I write C the set of households purchasing positive amounts of the good in at least one of the states.

Consumption from the home production endowment depends on the relative pre-tax price (sale price) of the good z_j and the marginal purchasing price $pD + (1 - D)(z_j + t_2)$. If the sale price is higher than the marginal purchasing price the household will always sell all its home production and purchase all it consumes from the market. This implies that if the tax schedule is such that $t_2 < 0$, both the net-of-tax market price and the ration price are lower than the sale price so households always sell their entire home production. Purchases are only affected by home production entitlements through income effects - when the pre-tax price is higher households that are net producers are richer, those that are net consumers are poorer. If the tax schedule is such that $t_2 > 0$ and the ration price is higher than the sale price households will only purchase positive amounts if their demand for the good cannot be satisfied by their endowment q, so we know that households that purchase positive amounts ($c > 0$) are consuming their entire endowment ($c_m = q$). Finally if the schedule is such that $t_2 > 0$ and the ration price is lower than the sale price households with low demand for the good will consume only from the ration shops and sell all their home production. Households which demand an amount of the good greater than the quota will on the other consume all their home production, and purchase the good at the net-of-tax market price if their demand is not satisfied when consuming the quota and their home production endowment.

3.3.2 Linear tax rate

The separability assumption allows me to consider each good separately. The linear tax rate is given by the standard Ramsey formula:

$$\frac{t}{\tilde{z} + t} = \frac{\int \int_I (\mu - g(\theta, q)) c(\theta, q) f(\theta, q) d\theta dq}{-\mu \tilde{\epsilon}_u \tilde{c}} \tag{6}$$

where $\tilde{c}$ is average consumption in the population, $c(\theta, q) = 0.5c_h(\theta, q) + 0.5c_l(\theta, q)$ is expected consumption for each household when the optimal linear rate t is levied, $\tilde{z}$ is the average pre-tax price and $\tilde{\epsilon}_u$ is the average uncompensated elasticity weighted by consumption shares: $\tilde{\epsilon}_u = \int \int \epsilon(\theta, q) c(\theta, q) f(\theta, q) h(q) d\theta dq / \tilde{c}$.

The sign of t is a product of two factors. The first is a revenue effect and depends on the distribution of $c(\theta, q) f(\theta) h(q)$. The second is a distribution effect and depends on the distribution of $\mu - g(\theta, q)$ and hence on the sign of $g'(\theta)$. The tax rate is higher if the welfare weight of households is small at points where the density of total consumption is high. Keeping the distribution of $f(\theta)c(\theta)$ constant t will therefore be higher for a normal good than for an inferior good, as less weight is placed on households consuming large amounts of c for a normal good.[21]

Home production enters the expression for the optimal linear rate by affecting purchase levels. When the good is taxed positively households consume all their endowment and hence purchase less on the market, when it is taxed negatively they sell all their endowment and therefore receive a positive income which affects their purchase through the income effect. If the good is normal households with higher home production endowments will, all else equal, purchase less of the good. This implies that they are given a smaller weight in the computation of the optimal tax rate. This will tend to decrease the optimal tax rate if richer households have higher endowments.

3.3.3 Redistribution motive

I start by considering for what kind of goods and government preferences a ration shop schedule will be welfare improving in the absence of price risk, $z = \tilde{z}$. Intuitively this will be the case if for some quota amount $\bar{c}$ decreasing the tax rate by a small amount dt below the quota increases welfare. The total impact on welfare of such a decrease dt is given by

$$dt[\int\int_{C_0}(g(\theta,q)-\mu)c(\theta,q)f(\theta,q)d\theta dq+\int\int_{C_2}(g(\theta,q)-\mu)\bar{c}f(\theta,q)d\theta dq+\mu\frac{t}{\tilde{z}+t}(-n_0\epsilon_0\tilde{c}_0+n_2\tilde{\eta}_2\tilde{s}_2\bar{c})] \tag{7}$$

where n_i is the share of households in I_i,$\tilde{c}_i$ their average consumption and elasticities are weighted averages over I_i: $\tilde{\epsilon}_i = \int\int_{Ci}\epsilon(\theta,q)c(\theta,q)f(\theta,q)h(q)d\theta dq/(\tilde{c}_i n_i)$ and $\tilde{\eta}_i = \int\int_{Ci}\eta(\theta,q)s(\theta,q)/\tilde{s}_i$.

The first two terms represent the net mechanical welfare effect of decreasing the tax rate for consumption under $\bar{c}$: households purchasing less than $\bar{c}$ receive a transfer equal to their consumption, those purchasing more than $\bar{c}$ receive a transfer equal to the quota amount. The last term is a behavioral effect: households purchasing less from the quota face a decrease in price and hence consume more, households purchasing more than the quota receive a transfer $dt\bar{c}$ which affects their consumption through the income effect.

Replacing with the expression for the optimal linear rate (6) and re-writing we see that (7) is equivalent to the total impact on welfare of increasing t above the threshold by dt:

[21] The assumption that $G'(v(\theta,q))$ is only a function of income implies that the optimal linear rate is not affected by price risk. This assumption facilitates the isolation of a price risk effect and hence a potential insurance benefit from introducing a ration shop system but can easily be relaxed. If households are on average net consumers of the good an increase in risk will entice the government to lower t to provide households some insurance against price risk (see Cowan (2002) for the role played by linear commodity taxes with price risk).

$$dt[\int\int_{C_2}(\mu - g(\theta,q))(c(\theta,q)-\bar{c})f(\theta,q)d\theta d + \mu\frac{t}{\tilde{z}+t}n_2(\epsilon_2\tilde{c}_2 + \tilde{\eta}_2\tilde{s}_2\bar{c})] \tag{8}$$

Here the net mechanical welfare effect consists of a transfer of revenues away from households consuming more than the quota towards the government as their consumption above the quota is being taxed more. The behavioral effect is a weighted sum of income and price effects: the increase in t over the quota is equivalent to an uncompensated increase in the price of the good combined with an increase in households' virtual income by $dt\bar{c}$.

It will be useful to consider the marginal welfare gain in the absence of risk per unit of revenue spent. This is the sum of a mechanical loss of μ for each unit, a redistribution effect $R(\bar{c})$ and a behavioral effect $B(\bar{c})$. A one unit decrease in t below $\bar{c}$ costs $\tilde{c} - n_2(\tilde{c_2} - \bar{c})$ so this can be written in the following way:

Proposition 1 *The marginal welfare gain per unit of revenue spent of introducing a ration shop schedule with a threshold $\bar{c}$ in the absence of risk can be decomposed into a redistribution effect $R(\bar{c})$ and a behavioral effect $B(\bar{c})$ in the following way:*

$$= -\mu + \underbrace{\frac{\int\int_C c(\theta,q)g(\theta,q)f(\theta,q)d\theta dq - \int\int_{C_2} g(\theta,q)(c(\theta,q)-\bar{c})f(\theta,q)d\theta dq}{\tilde{c} - n_2(\tilde{c_2}-\bar{c})}}_{R(\bar{c})} + \underbrace{a\frac{\int\int_I(\mu - g(\theta))c(\theta,q)}{\tilde{c} - n_2(\tilde{c_2}-\bar{c})}}_{B(\bar{c})} \tag{9}$$

where $a = \frac{-n_0\tilde{\epsilon}_0\tilde{c}_0 + n_2\tilde{\eta}_2\tilde{s}_2\bar{c})}{-\tilde{\epsilon}_u\tilde{c}} \in (0,1)$,$n_i$ is the share of households in I_i and $\tilde{c}_i$ their average consumption, and elasticities are weighted averages over I_i: $\tilde{\epsilon}_i = \int\int_{Ci}\epsilon(\theta,q)c(\theta,q)f(\theta,q)h(q)d\theta dq/(\tilde{c}_i n_i)$ and $\tilde{\eta}_i = \int\int_{Ci}\eta(\theta,q)s(\theta,q)/\tilde{s}_i$.

Introducing a ration shop schedule in the absence of price risk is welfare improving compared to levying linear tax rates if:

$$\begin{aligned} &\exists\bar{c} \in (c_{min}, c_{max}) \text{ such that} \\ &-\mu + R(\bar{c}) + B(\bar{c}) > 0 \end{aligned} \tag{10}$$

The redistribution effect $R(\bar{c})$ is increasing in the sum of marginal social welfare weights weighted by household purchases of the good $\int\int_C c(\theta,q)g(\theta,q)f(\theta,q)d\theta dq$, because introducing a ration shop schedule lowers the taxes paid on purchases of the good up to a quota limit for all households. This effect is larger for goods for which the correlation between $g(\theta,q)$ and $c(\theta,q)$ is negative, ie inferior goods. However the second term shows that for a constant weighted sum of weights the redistribution effect is also decreasing in the average weight of households consuming more than $\bar{c}$, as the ration shop schedule increases the relative marginal tax rate they are facing. This term is lower if households purchasing more of the good also have lower marginal welfare weights, ie the good is normal. Introducing a ration shop schedule can therefore have a positive welfare effect for both inferior and normal goods. The ideal candidate for convex taxation is a good that is inferior up to a a given purchase amount and then normal. A more realistic good candidate for convex taxation is a good that is normal, so that taxing higher purchase levels more transfers revenues away from richer households, but still widely consumed by the poor, so that taxing lower purchase levels less transfers revenues to them. On the contrary items not consumed by poor households (luxury items) are clearly not good candidates as for them the sum of marginal welfare weights weighted by household purchases will be low.

The behavioral effect is of the same sign as the optimal linear tax rate and is affected by the distribution of price and income elasticities in the population, as reflected by the term a. It is larger in absolute value the larger the price elasticity of demand amongst households purchasing small amounts relative to households purchasing large amounts. It is also decreasing in the income effect averaged over households with high purchases: the higher the income effect the higher the efficiency gain from introducing a lower (positive) tax rate below a threshold.

Finally expression (8) shows that a revenue-maximizing government would not implement a ration-shop schedule under most values of the demand parameters. Such a government sets a weight $g(\theta, q) = 0$ on all households so that (8) is of the same sign as

$$\tilde{c}_2(1 - \tilde{\epsilon}_2/\tilde{\epsilon}) + \bar{c}(1 - \tilde{\eta}_2/\tilde{\epsilon}) \tag{11}$$

This is negative unless $\tilde{\epsilon_2}$ is very small in absolute value compared to $\tilde{\epsilon_0}$ and/or $\tilde{\eta_2}$ is very large compared to $\tilde{\eta_0}$. This is the Maskin-Riley quantity-discount result applied to optimal taxation (Maskin and Riley, 1984): like a profit-maximizing monopolist a tax-revenue maximizing government would, if possible, choose to set a lower price to high-demand consumers to induce them to purchase more unless their purchases are substantially less price-elastic than the average. I assume concave taxes are not feasible so a revenue maximizing government will choose to levy a linear rate.

3.3.4 Insurance motive

Consider now the marginal welfare gain of introducing a ration shops schedule in the presence of price risk. This obtained by considering the case in which the government implements the highest possible ration price $p = z_l + t$ below a threshold $\bar{c}$: a change in the marginal price of the good below the quota of Δz in state h. The total impact of this change on welfare is given by:

$$\Delta z[\int\int_{C_{0h}} (g(\theta,q)(1+m)-\mu)c_h(\theta,q)+\int\int_{C_{2h}} (g(\theta,q)(1+m)-\mu)\bar{c}+\frac{t}{z_h+t}(n_{0h}\epsilon_{0h}\tilde{c}_{0h}+n_{2h}\tilde{\eta}_{2h}\tilde{s}_{2h}\bar{c})] \tag{12}$$

This expression differs from the welfare impact of introducing a ration shop in the absence of price risk (expression(7)) in two ways.First, terms are summed over households in state h

only as the change does not affect households in state l. Second, the marginal welfare weights of households is now $g(1+m)$ where $m = m(\theta, q, \Delta z)$ is the change in the marginal social welfare weights of a household when faced with the high price instead of the average price $\tilde{z}+t$:

$$m(\theta, q, \Delta z) = 0.5\frac{\Delta z}{\tilde{z}+t}[-\eta s + r\frac{(c+c_m-q)(\tilde{z}+t)}{R}] \tag{13}$$

When a household has no home production endowment or consumes it all ($c_{mh} = q$) its marginal weight is higher in state h as a higher price increases its marginal utility of income. This increases the value to the government of transferring resources to the households. When the marginal sale price is higher than the marginal purchase price households sell all their endowments so the marginal weight in state h of households with positive endowments is lower than that of households with no endowment as the higher price leads to an increase in income . Households which are net producers of the good ($c_h + c_{mh} - q < 0$) have a lower welfare weight ($m < 0$) when the price is high. Again it will be useful to consider the marginal welfare gain of introducing a ration shop schedule per unit of revenue spent.

Proposition 2 *The marginal welfare gain per unit of revenue spent of introducing a ration shop schedule with a threshold $\bar{c}$ in the presence of price risk can be decomposed into the redistribution effect $R(\bar{c})$, the behavioral effect $B(\bar{c})$ (as defined in (9)) and an insurance effect $I(\bar{c})$ in the following way:*

$$= -\mu + b(R(\bar{c}) + B(\bar{c})) + \underbrace{\frac{M + \int\int_{C_h} g(\theta,q)mc(\theta,q) - \int\int_{C_{2h}} g(\theta,q)m(c-\bar{c})}{\tilde{c_h} - n_{2h}(\tilde{c_{2h}} - \bar{c})}}_{I(\bar{c})} \tag{14}$$

where $b = \frac{\tilde{c}-n_2(\tilde{c_2}-\bar{c})}{\tilde{c}_h-n_{2h}(\tilde{c}_{2h}-\bar{c})}$, $M = 0.5[\int\int_{CB}(g(\theta,q)-\mu)\bar{c}f(\theta,q)d\theta dq - \int\int_{C_{0h}}(c(\theta,q)-c_h(\theta,q))(g(\theta,q)-\mu)f(\theta,q)d\theta dq]$ and I_B is the set of households which would consume more than $\bar{c}$ at $z=\tilde{z}$ but consume less than $\bar{c}$ at $z = z_h$.

Introducing a ration shop schedule in the presence of price risk is welfare improving compared to levying a linear tax rate if:

$$\begin{aligned} &\exists \bar{c} \in (c_{min}, c_{max}) \text{ such that} \\ &-\mu + b(R(\bar{c}) + B(\bar{c})) + I(\bar{c}) > 0 \end{aligned} \tag{15}$$

The insurance effect is increasing with relative risk aversion, price risk Δz and the good's budget share if we assume that households are on average net consumers of the good.[22] An increase in the share of the good in the budget of poorer households has a bigger impact on

[22] This is equivalent to assuming that part of the production of the good is done by firms that are outside the model.

$I(\bar{c})$ than an increase in this share for richer households. The distributions of the relative risk aversion parameter and home production endowments matter. If relative risk aversion is higher for households whose consumption is close to subsistence level (see for example Chetty and Looney (2006)) the insurance motive will be higher for all goods purchased by the poor. The distribution of home production endowments affects the insurance benefit of introducing the ration shop schedule as the gain to providing insurance is higher for households that are net consumers of the good. $I(\bar{c})$ will therefore be larger when poorer households have lower home production endowments (positive correlation between $g(\theta, q)$ and m).

If (14) holds a ration shop schedule in which the government only subsidizes the good in the bad state is welfare improving. If (9) also holds a ration shop schedule in which the government subsidizes the good in both states is welfare improving. This is the type of ration shop schedule implemented in many developing countries. Overall the model suggests that the introduction of a ration shop schedule can be (strictly) welfare improving for normal and inferior goods alike, but is unlikely to yield large welfare gains for luxury goods. The gains to introducing a ration shop schedule will be higher (higher $I(\bar{c})$ and $R(\bar{c})$) for normal goods that are widely consumed by the poor, when poorer households are net consumers of the good/richer households are net producers, the price risk is large and the good is a large share of household's budgets, particularly that of poorer households.

3.3.5 Optimal piecewise schedule

Proposition 3 *The optimal piece-wise convex tax schedule is given by (all variables are a function of θ and q unless otherwise specified):*

$$\frac{t_2}{\tilde{z}+t_2} = \frac{\int\int_{C2l}(c_l-\bar{c})(\mu-g(1+m(t_2))f(\theta,q)d\theta dq + \int\int_{C_{2h}}(c_h-\bar{c})(\mu-g(1+m(t_2)+m))f(\theta,q)d\theta dq}{-2\mu n_2(\tilde{\epsilon}_{u2}\tilde{c}_2+\tilde{s}_2\tilde{\eta}_2\bar{c})} \tag{16}$$

$$\frac{p-\tilde{z}}{p} = \frac{\int\int_{C0l}c_{pl}(\mu-g(1+m(p))f(\theta,q)d\theta dq+\int\int_{C_{0h}}c_{ph}(\mu-g(1+m(p)+m))f(\theta,q)d\theta dq+2\int\int_{CA}\bar{c}(\mu-g(1+m(t_2)+0.5m))f(\theta,q)d\theta dq}{-2\mu n_0\tilde{\epsilon}_{u0}\tilde{c_0}} - \left[\frac{\mu n_2\frac{t_2}{\tilde{z}+t_2}\tilde{s}_2\tilde{\eta}_2\bar{c}}{-\mu n_0\tilde{\epsilon}_{u0}\tilde{c_0}}\right] \tag{17}$$

$$\begin{aligned}&\int\int_{C1l}\mu(p-z_l)+\bar{v}g(1+m(p))f(\theta,q)d\theta dq+\int\int_{C1h}\mu(p-z_h)+\bar{v}g(1+m(p)+m)f(\theta,q)d\theta dq\\&=(z_l+t_2-p)\int\int_{C2l}\mu(1-\tfrac{t_2}{z_l+t_2}\eta s)-g(1+m(t_2))f(\theta,q)d\theta dq\\&+(z_h+t_2-p)\int\int_{C_{2h}}\mu(1-\tfrac{t_2}{z_h+t_2}\eta s)-g(1+m(t_2)+m)f(\theta,q)d\theta dq\end{aligned} \tag{18}$$

where $m(t_2)=\frac{s}{\rho}(r-\eta)(t_2-t)$ is the increase in the marginal value of income due to the higher tax rate on purchases above the quota, $m(p)=\frac{s}{\rho}(r-\eta)(p-z_l-t)$ is the decrease due to the decrease in the price of the good for purchases below the quota and $m = m(\theta, q, \Delta z)$ the impact of price risk as defined above. The term $\bar{v}$ captures the utility gain amongst households purchasing exactly $\bar{c}$ from increasing $\bar{c}$: $\bar{v}(\theta, q) = \frac{U'(\bar{c})-(1+m(p))\lambda(\theta,q)}{\lambda(\theta,q)}$. These households's marginal utility is higher than p but lower than $z_j + t_2$ so their marginal utility gain is bounded by the difference in prices implemented due to the tax schedule, $0 \leq \bar{v} \leq z_j + t_2 - p$.

The expression for the top commodity tax rate (16) closely resembles that for the top marginal income tax rate in Saez (2001) with social marginal welfare weights averaged over households that consume more than $\bar{c}$. Unsurprisingly t_2 is increasing in μ, decreasing in the social weight given those above the threshold $\bar{c}$, decreasing in the (absolute value of) demand elasticities, increasing in the income effect (for a given uncompensated elasticity, a higher income effect leads to a lower absolute value of compensated elasticity) and increasing in the ratio $\tilde{c}_2/\bar{c}$. The presence of price risk affects t_2 in the same way as the linear tax rate.[23]

The first line of the expression for the ration shop price (17) is similar to the formula for the linear rate: the ration price price is a function of the weighted sum of the net welfare gain from taxing households characterized by θ, q times their consumption. The expression differs by only weighing households which purchase more than the quota by $\bar{c}$ and not their actual purchase level, because only their purchases up to $\bar{c}$ are affected by p and the relevant price elasticity term is only averaged over households for which p is the marginal price. The ration price is therefore increasing in μ, decreasing in the social marginal welfare weight of those below the threshold and in the elasticity averaged across households below the threshold. The term on the second line of (17) shows the main difference between the expression for p and that for the linear rate and represents the extra behavioral effect of increasing p compared to increasing t - an income effect on households purchasing more than the quota. Positive income effects among households above the threshold lower p if $t_2 > 0$ as increasing p leads to less revenues collected on the tax base for t_2. This link with t_2 through income effects implies that the ration price for a normal good is increasing in the marginal weight of those above the threshold if t_2 is positive, decreasing otherwise.

Finally expression (18) equates the marginal cost and benefit of raising $\bar{c}$. The left-hand-side is the marginal benefit of raising $\bar{c}$ for households that are consuming exactly $\bar{c}$: the sum of the utility gain obtained from relaxing the constraint of households at $\bar{c}$ and the extra revenues collected from them (positive or negative). This must be equal to the marginal cost of raising $\bar{c}$ in the C_{2l} and C_{2h} regions which is the sum of a net welfare effect (less revenues are collected from households in these regions) and an income effect.

The next part of this paper uses the model's findings to ask for which goods and types of government preferences introducing a ration shop system is welfare improving in the Indian

[23] Note that one particular case is for values of $\bar{c}$ such that $c_h(\theta_{max}) < \bar{c}$. The price risk term drops out and, all else equal, the tax rate increases, as only households in state l will ever be faced with this tax rate. This is similar to the result of positive top marginal income tax rates in Varian (1980).

context.Formally, I first obtain the optimal linear tax rates t_k and the marginal value of public funds μ using expression (6) for each good category considered and the budget constraint (4). I then compute for each good the redistribution insurance and behavioral effects of introducing a ration shop defined by (9) and (14).

4 Data and method

This section details the data and method used to apply the model to the case of India in 2011-2012.

4.1 Data

I use the nationally representative 68th round of the annual consumption survey carried out by the Indian National Sample Survey Organisation (NSS survey). It contains detailed information on all goods consumed over the last month by nearly 60,000 rural households and 42,000 urban households and was carried out between July 2011 and June 2012. My sample includes the 517 districts within the twenty largest states of India except Jammu and Kashmir.[24] The survey is stratified by urban and rural areas of each district and by quarter of the year in order to be representative at that level and I use the household level weights provided by the NSSO.

The questionnaire asks households to report for each good i)their purchases from the ration shops ii) their market purchases iii) their consumption from home production. Households also report both the quantity and the value of the goods purchased. This allows me to use unit values (ratios of values to quantities) for each good and household as proxies for the price of the good when sold on the market and when sold through the ration shops. I aggregate item level consumption into seven good categories: rice, wheat, sugar, kerosene, coarse cereals, pulses and 'meat and fish'.[25] These seven categories are of intrinsic interest. The first four are distributed through the ration shop system, coarse cereals (mostly maize, bajra and jowar) are sometimes described as goods that should be included in the ration shop system because of their low cost and high nutritional content (Dreze, 2009) and pulses, meat and fish are examples of goods with a large and positive income gradient but still consumed by a majority of the population. There are also categories for which estimates of price and income demand elasticities are available and take a wide range of values. Together these seven categories represent just over 15% of household consumption on average.

[24]Excluding small states and Jammu and Kashmir is standard practice as there are issues with sample representativeness in these states.

[25]This aggregation is chosen to group items that are close substitutes, to match the model's separability assumption.

This survey is typical of consumption surveys that are routinely done in developing countries - though considered to be of high quality it shares the same drawbacks (seeDeaton (1997) for a detailed description of the survey) . First, it does not attempt to directly measure income. I use total consumption expenditures as a proxy for income, following the literature and the methodology used by the NSSO itself. This leads me to underestimate the income of the richest households that are also typically under-represented in consumption surveys. The numerical analysis is therefore unable to consider the extent to which the ration-shop schedule taxes the super-rich, a fairly untapped source of government revenues in India (Piketty and Qian, 2009).[26] Second, the use of survey data implies that all variables are likely to be measured with error, in particular unit values. I compare unit values from the survey to price measures by the rural price collection survey undertaken by the NSSO at the village level to compute the rural consumer price index and find remarkably similar distributions in both datasets.[27] This dataset is only available for rural areas so cannot be used to perform the numerical analysis, but the comparison suggests unit values are a reliable proxy for prices.

4.2 Methodology

This section details which moments of the data and preferences parameters I use for the analysis. Table 3 summarizes the value taken by the parameters and their source.

4.2.1 Household and market characteristics

I obtain the joint distribution of income and purchases (both per capita) of each good directly from the survey and use household weights provided by the NSSO to measure the density of households at each point in the distribution. The survey does not ask about home production directly but reports the amount of land each household owns L^i and their total consumption from home production c^i_{km}. In line with the model's assumption that home production is an endowment I assume that household's home production is a deterministic function of its land, $q^i_k = q_k(L^i)$ where the production function $q_k(.)$ varies at the district level. I use household's reported consumption from home production c^i_{mk} to estimate the relationship between land and consumption from home production $\hat{q}_k(.)$ in each district. Goods that are produced at home (rice, wheat and coarse cereals) are not taxed in the period considered so the model predicts that households are indifferent between selling and consuming their endowments. Assuming a small cost of taking the goods to the market implies that households will consume all their home production and hence that consumption from home production is equal to the endowment for households that report purchasing positive amounts of the good ($c^i_{mk} = q^i_k$).

[26]This limitation of the data mirrors a limitation of commodity taxation in practice: progressive taxation of the super-rich is unlikely to be achieved through commodity taxes.

[27]Results available from the author upon request.

Under these assumptions I can attribute to each household an endowment $\hat{q}_k^i = \alpha \hat{q}_k(L^i)$ where $\alpha = 1$. I also consider cases where $\alpha > 1$ as a robustness check.

I use variation in prices within district and over time as a measure of price risk The NSS survey is annual, I compute unit values from the surveys for the years 1998-1999 to 2011-2012 and use median within district variations over time to proxy for Δz, where a time unit is a quarter. I use the difference between the top and bottom 5th percentiles as a baseline. To avoid capturing variations that are due to changes in the item-level composition of consumption in each good category I consider the price variation of the most widely consumed item in each good category.

4.2.2 Policy parameters

The formulas cannot be directly applied using the observed joint distribution of income and consumption in the NSS survey because consumption amounts are affected by the tax schedule. To simulate hypothetical consumption for alternative tax schedules one needs to specify demand elasticities and the existing tax schedule (t_0 for goods taxed linearly and $t_{20}, p_0, \bar{c}_0$ for the goods that are sold in the ration shops). I use the VAT rate levied by each state on each good as the linear rate t_0 or the high tax rate t_{20} for goods that are sold in ration shops. The parameters $p_0, \bar{c}_0$ are not uniformly defined across households: states set the parameters of the ration shops and both the price and the quotas can vary depending on household characteristics within a state. Moreover, there is anecdotal evidence that de facto quota amounts and prices vary across districts for benign reasons (irregular supply, transport costs explicitly included in the price in some states) and less benign ones - corrupt ration shop keepers.

I derive proxies for the policy parameters p_0 and $\bar{c_0}$ using households' reported purchases from the ration shops. I take the median value of the ration price at the districtxsector level, where a sector is the urban or rural part of the district, and apply this as a proxy for p_0 to all households in the districtxsector. Each district will have several hundred ration shops but the survey is not meant to be representative below the districtxsector level so this is the best available proxy for the ration price a household faces. Similarly I use as a proxy for the quota $\bar{c_0}$ for a good the median ration shop purchases of households that purchase positive amounts on the market in a districtxsector. The market price is always higher than the ration price so households that are purchasing positive amounts from the market must have exhausted their quota from the ration shops.[28] Their ration shop purchases are therefore a good proxy for the typical quota faced by households in their districtxsector. This median includes households which do not report purchasing the good from the ration shops, assuming that they did not use ration shops because they are not available or no longer hold the good in stock. Alternatively, one may think that these households chose not to use the ration shops; I also consider median

[28] I exclude the few (less than 0.05%) households for which the ration unit value is higher than the market unit value, as this is likely due to measurement error.

ration shop purchases of households that report purchasing positive amounts both on the market and from ration shops as a proxy for $\bar{c_0}$ as a robustness check.

4.2.3 Preference parameters

The model does not constrain the demand parameters to be equal across households, but in what follows I assume for simplicity that $\epsilon_u^i = \epsilon$, $\eta^i = \eta$ and $r^i = r$. Elasticity estimates for India are scarce, let alone estimates of their heterogeneity. I consider baseline values of $\epsilon = -0.3$ and $\eta = 0.1$ for all goods. I consider estimates of ϵ_u and η for the different good categories obtained by Kumar *et al.* (2011). Meat and fish have high price and income elasticities, rice has low price and income elasticities and pulses and coarse cereals is the only good category for which Kumar *et al.* (2011) find a negative income effect. Deaton and Subramanian (1994) provides alternative estimates of ϵ for each good category except kerosene. I use $r = 3$ as a baseline, in line with experimental estimates found by Carlsson *et al.* (2003) amongst Indian subjects.

I consider two forms of social welfare functions, a standard welfare function and a poverty-averse function. In both cases I assume that social marginal welfare weights $g(\theta, q)$ vary as a function of real income and not indirect utility $v(.)$. This assumption implies that I do not need to specify and estimate a particular form of utility function to compute the marginal effect of introducing a convex system, it substantially simplifies the numerical exercise and the study of the extent to which results are robust to assumptions regarding household demand. The poverty-averse welfare function is composed of two marginal weights $g_p > g_r$ where g_p is the weight given to poor household and g_r to rich households. I set $g_p = 2$ an $g_r = 1$ at baseline and use the Tendulkar state-specific poverty lines for 2011-2012 to define a household's poverty status. I consider a constant relative inequality aversion welfare function characterized by marginal weights $g(y) = Wy^w$, where the parameters W and w are calibrated so that the average weight of the poor is equal to 2 and that of the non-poor equal to 1, to make results comparable across forms of welfare functions.[29] I use the poverty-averse function as baseline and show that results are qualitatively very similar when using a standard social welfare function. Finally, I set the revenue requirement E to be equal to the (simulated) total taxes paid on the seven good categories minus the ration subsidies at baseline. The ration shop schedule has a net cost equal to 0.06% of total observed consumption on these seven goods.

[29] $W = 365$ and $w = 0.8$.

5 Application: India, 2011-2012

5.1 Baseline results

This section presents estimates of the redistribution and insurance effects per unit of revenue spent of introducing a ration shop schedule for different goods defined in expressions (9) and (14) for India in 2011-2012. The key characteristics of the good that the model predicts are relevant for these two effects are presented in Table 4, as well as the optimal linear rates for each good, obtained using (6).

Figure 5 presents baseline results using uniform elasticities and using the elasticity estimates in Kumar *et al.* (2011) and Deaton and Subramanian (1994). I show net redistribution and insurance effects, ie the redistribution or insurance effect as defined above minus the cost to the government of spending one unit of revenue plus the behavioral effect ($R(\bar{c}) + B(\bar{c}) - \mu$,$I(\bar{c}) + B(\bar{c}) - \mu$). There is one value of each effect per potential quota level $\bar{c}$, I discuss the average value in this section but results are very similar - the ranking of goods is unaffected - if we consider the maximum value or the share of potential quota levels for which the effects are positive.[30] The first panel graphs the net redistribution effect for each of the seven good categories selected and the second panel the net insurance effect. Several conclusions can be taken from the graph.

First, results are not very sensitive to using different values of the demand parameters. The ranking of goods for both types of effects in particular is unaffected by the choice of demand parameters. The one exception is the redistribution effect for coarse cereals which is substantially lower when using the elasticity estimates in Kumar *et al.* (2011). This is due to the fact that Kumar *et al.* (2011) finds a negative income effect for coarse cereals: the optimal linear tax rate for coarse cereals is positive so a negative income effect implies that households consuming more than the quota will decrease their purchases of coarse cereals when a ration shop is introduced, increasing the behavioral effect. The overall lack of sensitivity of the results to the choice of demand parameters indicates that behavioral effects, which are determined by those parameters, are very small compared to redistribution and insurance effects. Values of the redistribution and insurance effects for all specifications of the parameters are reported in Appendix Table 5.

Second, net redistribution effects are positive only for rice, kerosene and wheat, three goods that are currently in the Indian ration shop system. These three goods approximate the ideal scenario outlined in the theory section: they are consumed (slightly) more by the non-poor than by the poor but are consumed by most poor households. The gains are largest for rice, which constitutes a large share of households' budget (8.5% for the poor, 5% for the non-poor). The budget share of kerosene is much smaller but it is consumed by over 90% of poor households. Interestingly the net redistribution effect is negative for sugar on average,

[30] Appendix Figures 10 to 16 plot the net effects by quota level for each good.

another good currently distributed in the Indian ration shop system. This is because sugar, whilst consumed by over 90% of poor households, has an income gradient that is too high: the non-poor consume twice as much sugar than the poor so the redistribution effect is only positive for low quota levels and at those levels the gains are small. The net redistribution effect is negative for the three good categories considered that are not currently part of the ration shop system: purchases of pulses and meat and fish have a profile similar to that of sugar (though meat is only consumed by roughly half of the population) and coarse cereals are consumed by a too small share of the poor to make introducing a ration shop schedule worthwhile.

Finally we see that the net insurance effect, whilst positive for most goods, is largest for rice, wheat, coarse cereals and (to a lesser extent) kerosene. This is explained by high price risk for rice, wheat and kerosene - see Table 4. The price risk for coarse cereals is much lower but the income effect for this good category is low, leading to high responses of social marginal welfare weights to price risk, and it is consumed more by the poor. The price risk for meat is high, close to that for kerosene and wheat, but this does not translate into high insurance gains because the non-poor consume more meat and hence bear most of the price risk. The net insurance effect is very close to zero for sugar and pulses, goods for which the price risk is low.

5.2 Robustness and heterogeneity

Figure 6 compares net redistribution and welfare benefits obtained using a poverty-averse welfare function and a standard constant relative inequality aversion social welfare function, where the average marginal welfare weight of the poor and the non-poor are the same with both welfare functions (2 for the poor, 1 for the non-poor). Both effects are similar or slightly bigger are higher for all goods when the government has welfarist preferences. This is due to the fact that the consumption profiles of households just above the poverty line is very similar to that of households below the poverty line: the poverty-averse function gives the same weight to those households as to the richest households but the welfarist function values them more. These households in particular consume more kerosene than average, and slightly more meat than poor households; we see that the changes are largest for these two categories.

The baseline estimates assume the government spends roughly 0.6% of total consumption on the seven goods, in line with what is observed in India. Figure 7 considers the marginal benefit of introducing a ration-shop schedule if the entire commodity tax system has to be self-financing ($E = 0$) in the middle panel and if the tax system has to generate 0.6% of total consumption in tax revenues. As the exogenous revenue requirement increases so does the marginal value of public funds and therefore the costs of spending a unit of revenue on a ration shop schedule: we see that the gains are smaller for all goods, but the ranking of goods is the same as in the baseline scenario.

Poor households in developing countries are (by definition) much closer to subsistence levels of consumption than richer households. One way of capturing this idea is to assume that non-poor households have lower risk aversion. I set the relative risk aversion parameter of non-poor households to 1 (leaving it at 3 for poor households) in Figure 8. The overall benefits of spending public revenues in a ration shop schedule fall for all goods, as expected, but the ranking of the goods is unaffected.

Two types of results for subsamples of the population are of interest. First, rural and urban households have different home production endowments and may have different consumption patterns, kerosene for example is the primary energy used for lighting in rural areas but is mostly used for cooking in urban areas (UNDP, 2003). The government could in theory distribute different goods through ration shops in urban and rural areas, indeed coverage of rural areas was much poorer until the mid 90s, when the opening of new ration shops in rural areas started to mitigate the 'urban bias' of the system (Dev and Suryanarayana, 1991, Himanshu, 2013). Figure 9 presents results separately for urban and rural households. Results show that different kinds of goods should be included in the ration shop system in urban and rural areas. Insurance and redistribution gains for rice are very large in rural areas but not in urban areas, despite the fact that some rural households produce rice, reflecting the much higher budget share of rice among rural households. The net redistribution effect is negative for kerosene in rural areas but large in urban areas, because kerosene is consumed by the poor more than the non-poor in urban areas and the reverse in rural areas. Sugar, cereals, pulses and meat and fish are bad candidates for inclusion in the ration shop system in both rural and urban areas.

Second, the type of goods which should be included in the ration shop system is likely to vary by state, because household preferences for commodities differ by region (Atkin, 2013) and state-level poverty rates differ greatly. Appendix Table 6 presents the net redistribution and insurance effects obtained using the baseline specification for each state separately. We see that results are affected by the different regional household preferences, in particular the redistribution and insurance effects are small or negative for rice in the North-Western states of Gujarat, Punjab, Rajasthan and Haryana. They are on the contrary particularly large in the poorest states of the North-East in which poor households purchase a lot of rice. Redistribution and insurance effects for kerosene vary greatly across states, unsurprisingly they are lowest in the most rural states (Bihar, Orissa, Uttar Pradesh) and highest in the most urban states (Gujarat, Punjab, Delhi). Net redistribution effects are always negative for sugar, meat and pulses. They are positive for coarse cereals in a few states in which the net redistribution effects for both rice and wheat are negative or very small, suggesting that the government may find it optimal to tax another cereal staple non-linearly.

6 Conclusion

This paper shows that a particular tax instrument found in developing countries - piecewise convex commodity taxes implemented through ration shops - are part of the optimal tax mix when we take into account the particular characteristics of these countries. Non-linear commodity taxes play a redistributive role as soon as we restrict what standard public finance models typically take for granted, governments' capacity to observe households' incomes. I show that in this context introducing a ration shop schedule can be welfare improving for most types of goods and will yield largest gains for normal goods that are commonly purchased by poor households. Taking into account a particular characteristic of markets in developing countries - variations in producer prices due to market fragmentation - introduces another potential motivation for introducing a ration shop schedule. By setting the price of a quota amount of consumption at a fixed level such a schedule provides households with (partial) insurance against price fluctuations.

Applying the model to India shows that ration shop schedules are welfare improving compared to linear commodity taxes for rice, wheat and kerosene under a wide range of households and government demand parameters. This in line with the model's predictions and with the policy currently implemented by the Indian government as these three goods are currently distributed through the ration shop system in India. Sugar is also distributed through the ration shop system but I find that the welfare gains to taxing sugar non-linearly are null or negligible, suggesting that the phasing out of sugar from the system, often discussed in policy debates, would increase welfare.

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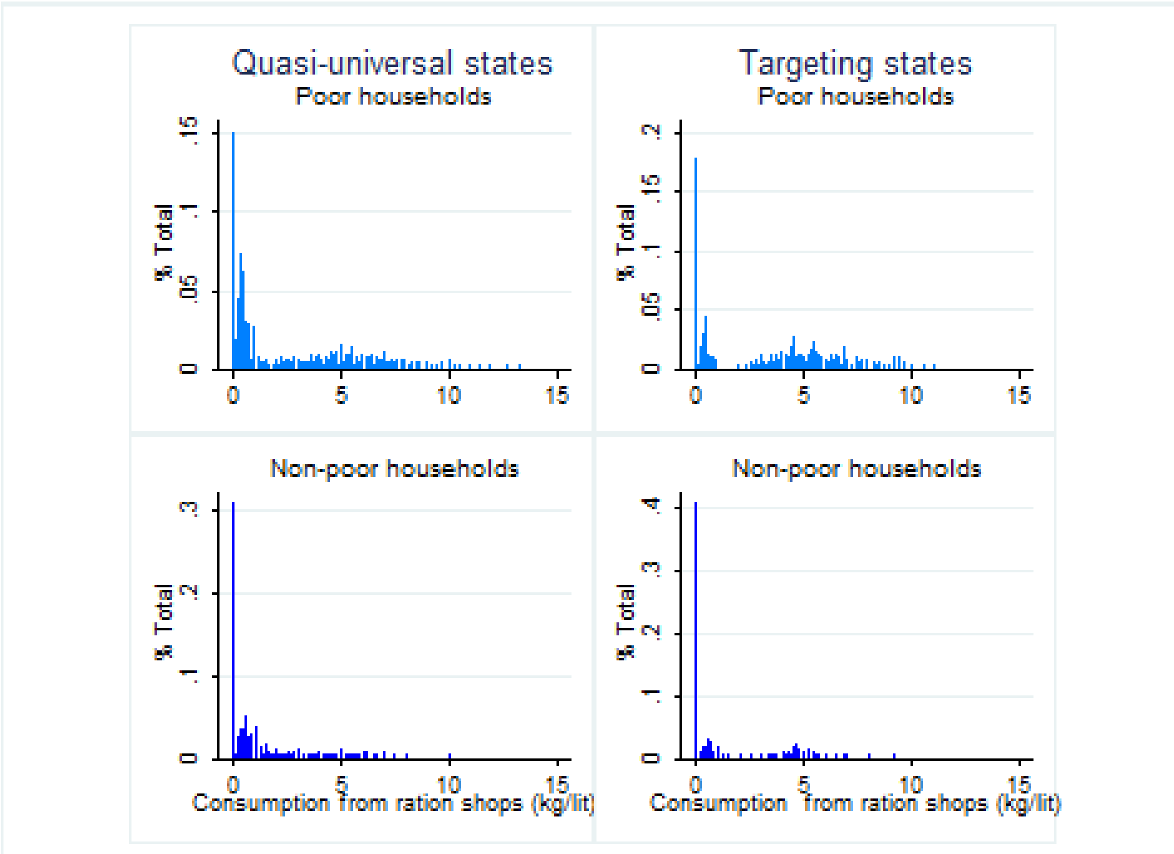
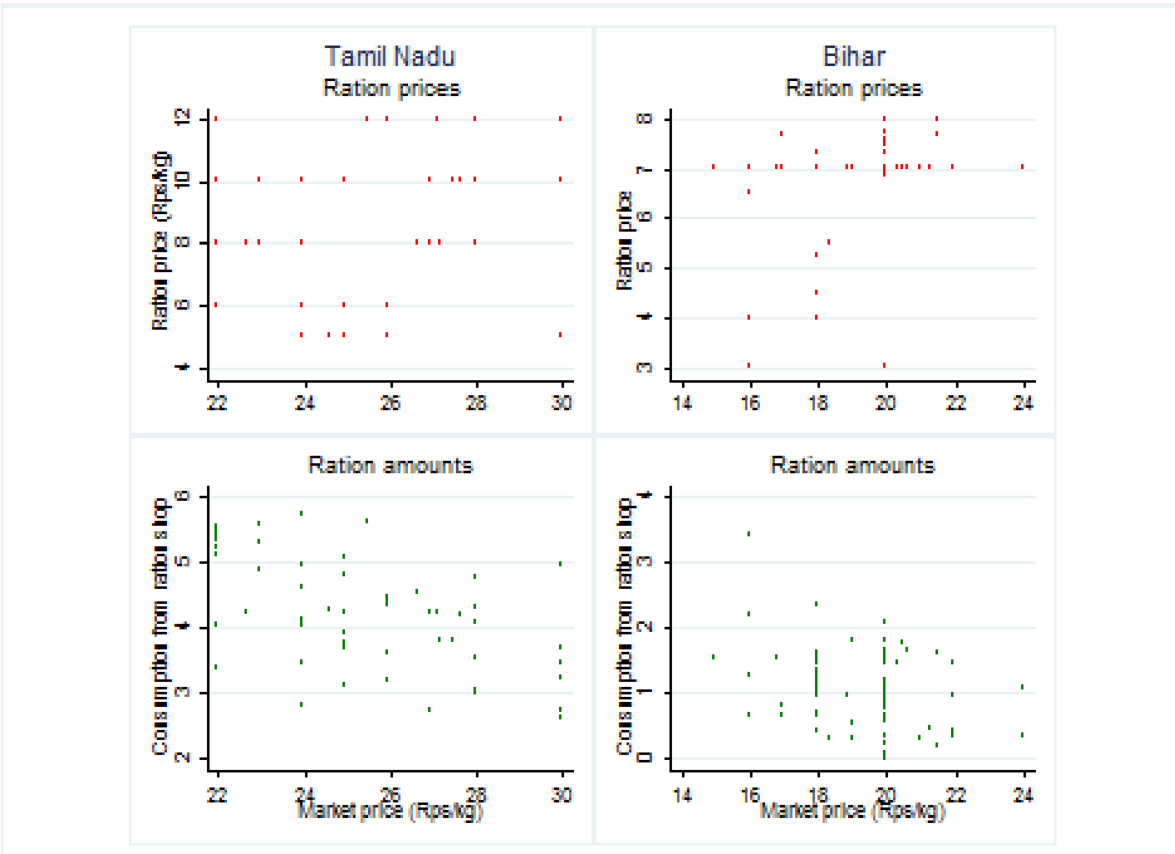
Figure 1: Total consumption from ration shops



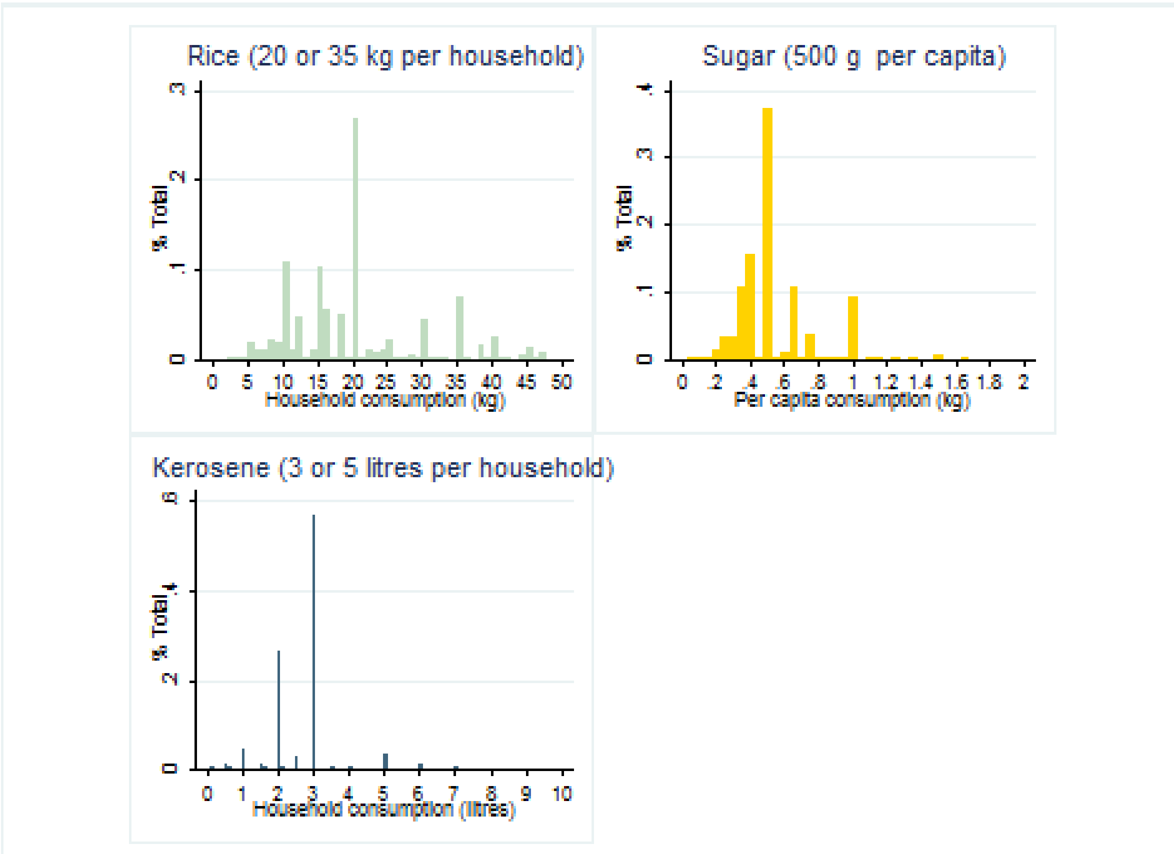
Distribution of total consumption per capita from ration shops: kilos of rice, wheat and sugar, litres of kerosene. Source: NSS survey consumption module 2011-2012. See the text for a description of the data. Quasi-universal states are states in which all households are eligible to use the ration shop system (Gujarat, Kerala, Madhya Pradesh, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal), they represent roughly 50% of the households in the sample.

Figure 2: District level correlations between market prices and ration prices and amounts for rice



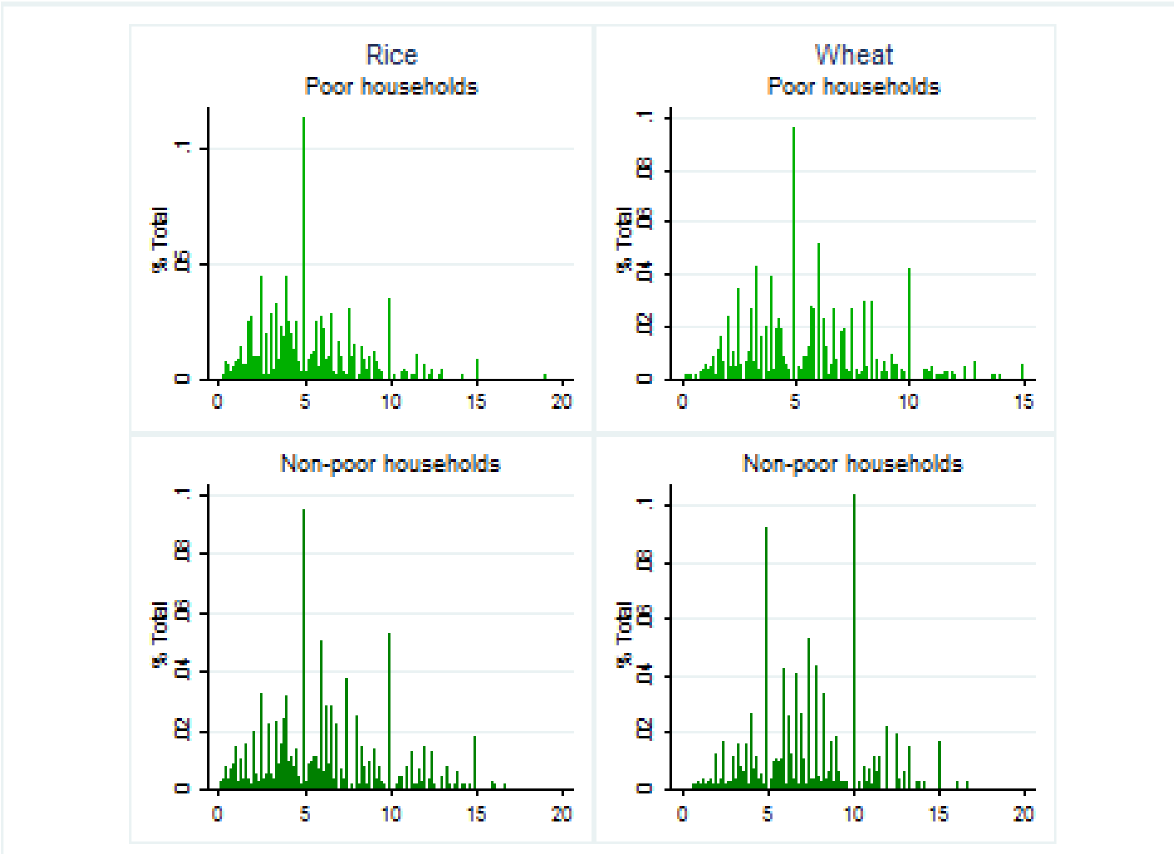
Median ration and market prices at the districtxsector level where a sector is urban or rural in Tamil Nadu and Bihar. I use unit values as a proxy for prices. Source: NSS survey consumption module 2011-2012. See the text for a description of the data.

Figure 3: Consumption from the ration shops in Tamil Nadu (official quota amount)



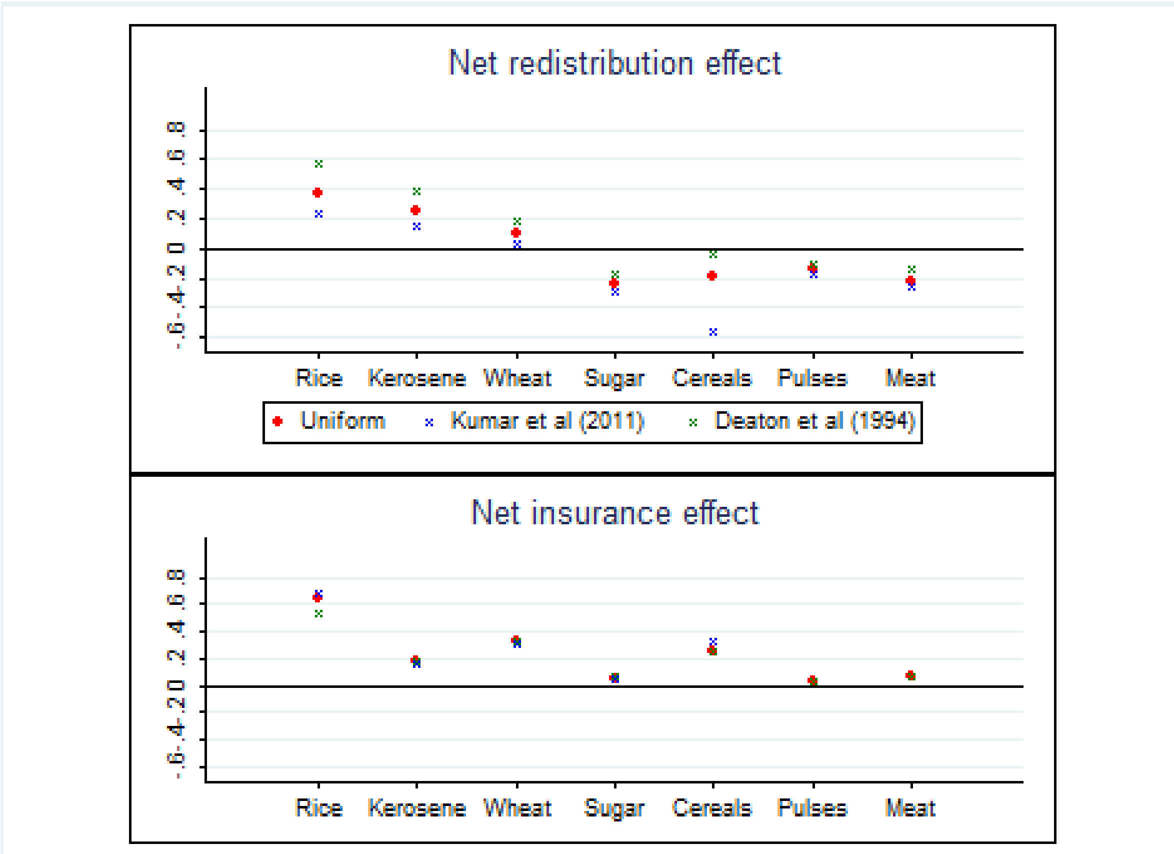
Distribution of consumption from the ration shops in Tamil Nadu for the three main goods sold in the ration shops. Consumption per household for rice and kerosene, per capita for sugar. Source: NSS survey consumption module 2011-2012. See the text for a description of the data.

Figure 4: Home production of rice and wheat



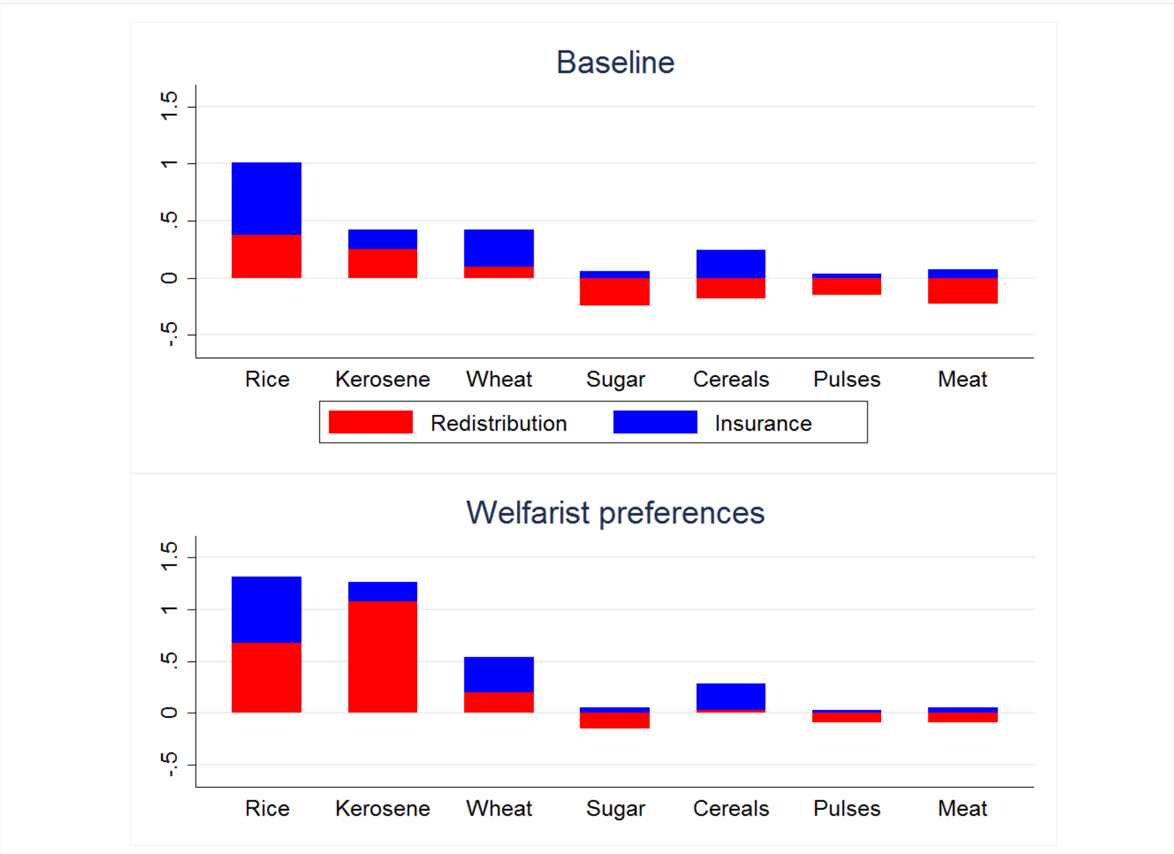
Distribution of consumption per capita from home production. Source: NSS survey consumption module 2011-2012. See the text for a description of the data.

Figure 5: Baseline results



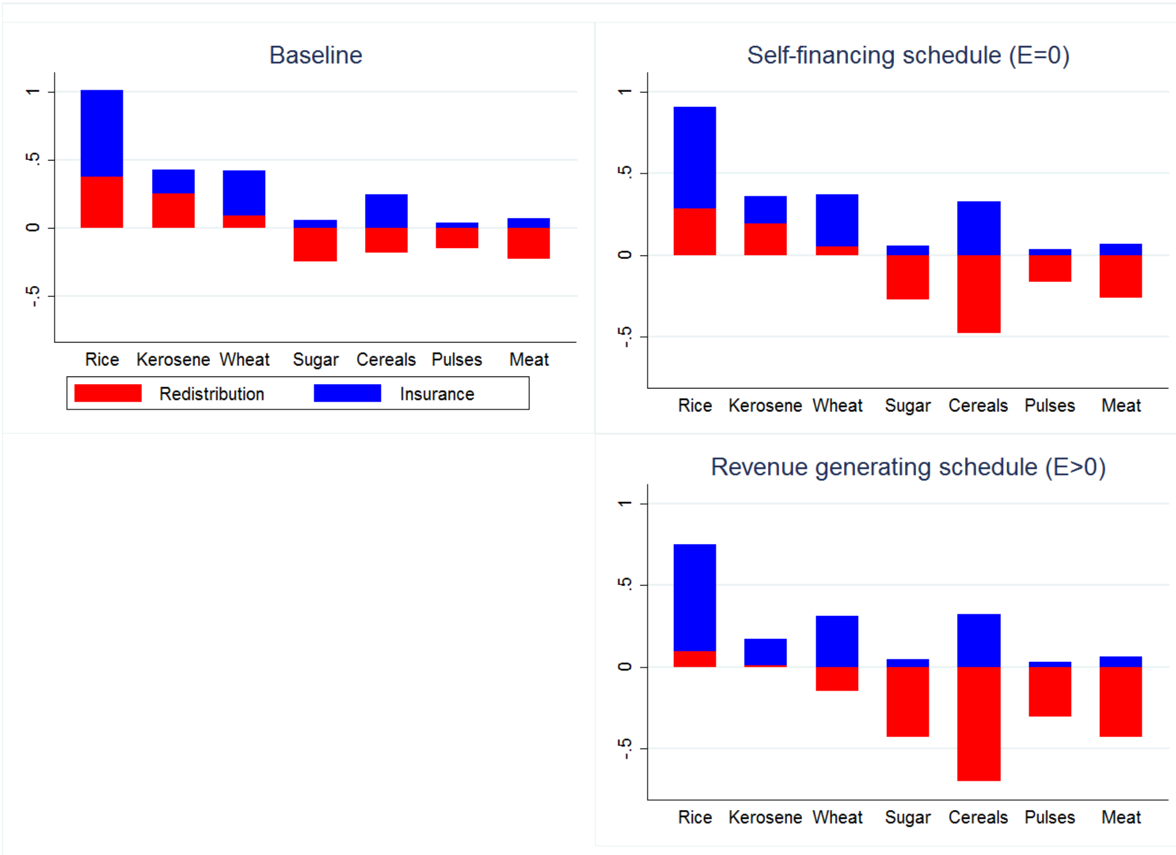
A point is the net redistribution effect (top panel) or net insurance effect (bottom panel) per unit of revenue spent of introducing a ration shop schedule for each good. Baseline estimates (in red) are obtained using uniform values of the demand parameters across goods, estimates in green are obtained using demand parameters estimated by Kumar *et al.* (2011) or Deaton and Subramanian (1994). The government is assumed to be poverty-averse. See the text for a description of the data and parameters used.

Figure 6: Results with welfarist preferences



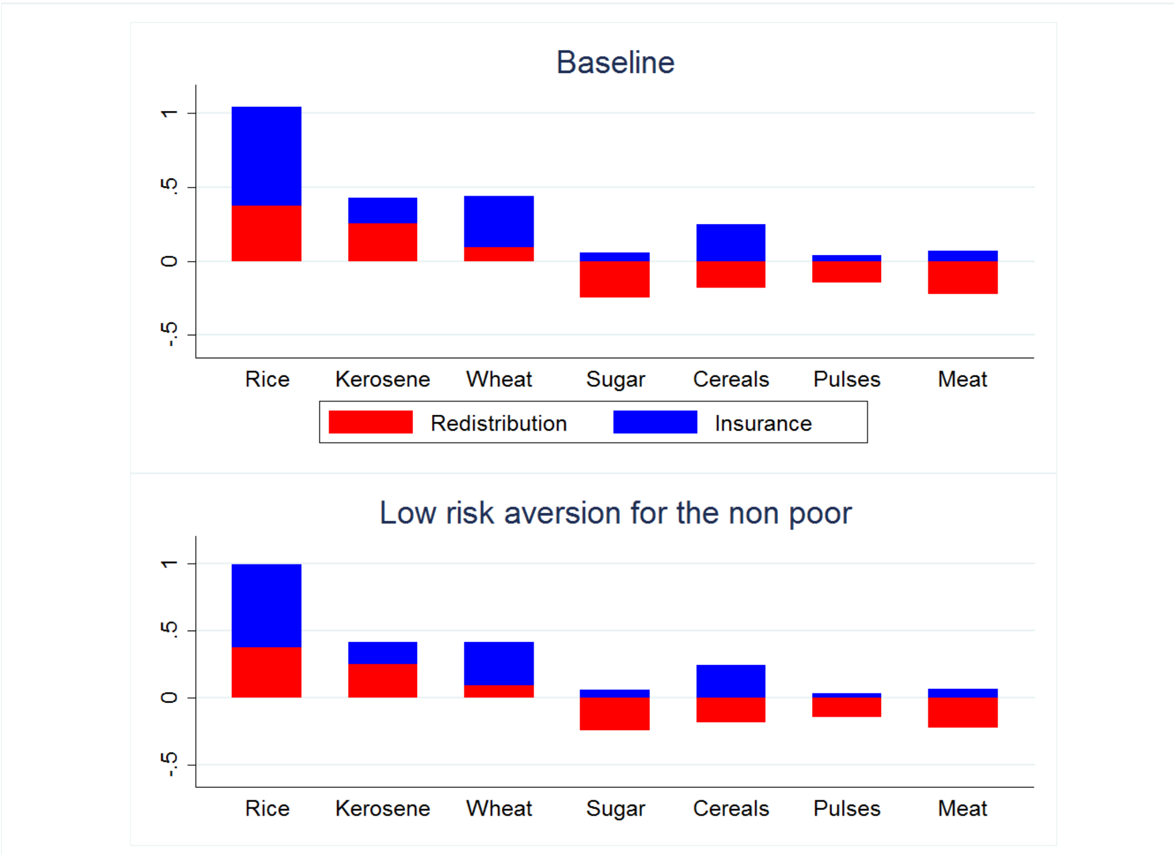
Net redistribution (in red) and insurance (in blue) effects of introducing a ration shop schedule for each good. See the text for a description of the data and parameters used. The government is assumed to be poverty-averse in the top panel and inequality-averse (standard welfare function) in the bottom panel, the demand parameters take the same values for all goods.

Figure 7: Results for different budget requirements



Net redistribution (in red) and insurance (in blue) effects of introducing a ration shop schedule for each good. See the text for a description of the data and parameters used. The government is assumed to be poverty-averse and the demand parameters take the same values for all goods.

Figure 8: Results with low risk aversion of the non-poor



Net redistribution (in red) and insurance (in blue) effects of introducing a ration shop schedule for each good. See the text for a description of the data and parameters used. The government is assumed to be poverty-averse and the demand parameters take the same values for all goods.

Figure 9: Results for rural and urban households separately

Net redistribution (in red) and insurance (in blue) benefits of introducing a ration shop schedule for each good. See the text for a description of the data and parameters used. The government is assumed to be poverty-averse and the demand parameters take the same values for all goods.

Table 1: Non-linear-commodity taxation in the developing world: examples of subsidies below a quota

Country	Period	Eligibility	Goods	Implementation	Cost
India	Since 1939	Universal till 1997, partially targeted since, shift back to universality in recent years	Wheat and rice. kerosene and sugar in some states.	Ration shops	1% of GDP
Pakistan	Until 1987	Universal	Wheat	Ration shops	15% of public expenditures
Sri Lanka	Until 1979	Universal	Rice, flour, sugar	Ration shops	
Sri Lanka	Since 1979	Targeted	Rice, flour, sugar	Food Stamps	9% of public expenditures
Bangladesh	Until early 1990s	Universal	Foodgrains	Ration shops	30% of public expenditures
Colombia	Until 1990s	Universal	Food		8% of public expenditures
Mexico	Since 2004	Targeted	Food	Ration shops	2% of public expenditures
Egypt	Since 1970s	Universal	Flour and bread	Ration shops	Up to 15% of public expenditures in the 90s

Sources: Planning Commission (2005), PRS (2013), Alderman and von Braun (1984), Kramer (1990), Islam and Garrett (1997), Ahmed (1988), Farrar (2000), Cunha *et al.* (2011).

Table 2: The ration shop system in India: descriptive statistics

	Rice (kg)	Wheat (kg)	Kerosene (lt)	Sugar (kg)
% Consumption from ration shops	28	17	72	15
%Households purchasing from ration shops	40	30	62	29
Typical ration quota	17	15	1.8	0.5
Median ration price	4.9	5.9	15.5	14.6
Median market price	21.3	16.3	28.4	32.9
Average household monthly consumption:				
All sources	24.1 (21.3)	19.4 (20.4)	2.3 (2.4)	2.3 (1.9)
From ration shops	6.1 (4.7)	2.9 (6.4)	1.7 (1.1)	0.4 (0.3)
From home production	4.6 (14.10	5.1 (15.8)	0	0

Source: NSS survey consumption module 2011-2012. See the text for a description of the data.

Table 3: Parameters used in the calibration

	Baseline	Alternatives
Household consumption and income		
Purchases c	Per capita monthly purchases in NSS 2011-2012	
Home consumption c_m	Per capita monthly home consumption in NSS 2011-2012	
Home production endowments q	Estimated $\hat{q}$ from land possessed in NSS 2011-2012	No home production.
Density distribution $f(\theta, q)$	Household weights in NSS 2011-2012	
Prices z_h, z_l	Median within district top and bottom 5th percentiles from NSS 1998-1999 to 2011-2012.	Top and bottom 10th and 1st percentiles.
Policy parameters		
Linear tax rate t_0	State level VAT rates in 2011	
Tax rate over the quota t_{20}	State level VAT rates in 2011	
Ration price p_0	Median ration price in each districtxsector	
Ration quota $\bar{c}_0$	Median purchase from ration shops among households purchasing from the market in each districtxsector	Median purchase from ration shops among households purchasing from the market and the ration shop
Preferences		
Price elasticity ϵ	-0.3	Estimates from Kumar et al (2011) and Deaton et al (1994)
Income elasticity η	0.1	Estimates from Kumar et al (2011)
Relative risk aversion r	3 (Carlsson et al, 2003)	r(poor)=3, r(non-poor)=1
Government preferences	Poverty averse: g(poor)=2, g(non-poor)=1	Welfarist: g(y)=Wy^{-w}, W=365, w=0.8.
E	-0.06% of consumption	0, +0.06% of consumption.

Price elasticities in Kumar *et al.* (2011) are -0.2 (rice) -0.8 (meat and fish) -0.2 (coarse cereals) -0.3 (sugar) -0.4 (pulses) -0.3 (wheat), in Deaton and Subramanian (1994) they are -1.19 (rice) -1.08 (meat) -0.52 (coarse cereals) -0.2 (sugar) -0.53 (pulses) -1.29 (wheat). Income elasticities in Kumar *et al.* (2011) are 0.02 (rice) 0.7 (meat) -0.1 (coarse cereals) 0.06 (sugar) 0.2 (pulses) and 0.08 (wheat).I set the price and income elasticities of kerosene to -0.3 and 0.1 in all calibrations.

Table 4: Key characteristics of the commodities considered

Good category	% households with positive purchases		Average per capita purchases when positive		Budget share		Price variation ($\Delta z/z_l$)	Optimal linear rate
	Poor	Non-poor	Poor	Non-poor	Poor	Non-poor		(% market price)
Rice	88	84	4.9 (3.9)	5.3 (4.4)	8.5 (8.4)	5 (5.5)	0.73	-12.4
Wheat	79	83	3 (3.1)	3.2 (3.6)	4.4 (3.7)	2.9 (3.1)	0.58	-3
Kerosene	92	70	0.59 (0.47)	0.61 (0.90)	1.2 (1)	0.05 (0.07)	0.6	0.6
Sugar	95	95	0.42 (0.33)	0.84 (0.60)	2.1 (1.1)	1.5 (0.8)	0.19	9.2
Coarse cereals	17	19	0.33 (1.1)	0.34 (1.2)	0.07 (2.2)	0.03 (1.2)	0.29	4.5
Pulses	92	93	0.5 (0.32	0.83 (0.59)	3.1 (2.4)	2.9 (1.9)	0.28	9.9
Meat & Fish	55	58	0.21 (0.33)	0.47 (0.86)	2.8 (3.6)	2.9 (3.7)	0.59	10.8

Source: NSS survey consumption module 2011-2012 for columns 2-7. The sample includes 67,533 non-poor households and 15,608 poor households. Consumption modules from the annual NSS survey 1998-1999 to 2011-2012 for column 8, and computation by the author for column 9. The optimal linear rates in the last column are estimated following expression (6) and assuming that the commodity tax system is self-financing ($E = 0$). See the text for a description of the data and the parameters used.

A Appendix

A.1 Theory appendix

A.1.1 Consumer maximization

I omit subscripts k and superscripts i in what follows for clarity and consider the general case with fixed producer price z, results extent naturally to cases where $z = z_h$ and $z = z_l$. c, c_m, D, p, $\bar{c}$, z, t_2 and q are vectors of length k defined in the text. The consumer's maximization problem is the following:

$$\begin{aligned} \max \quad & U(c + c_m) \\ \text{s.t} \quad & pcD + (1 - D)[p\bar{c} + (z + t_2)(c - \bar{c}) \leq y + z(q - c_m) \\ & q \geq c_m \end{aligned} \tag{19}$$

The level of consumption from home production is given by the comparison between the marginal price of consumption from the market $(z + t_2)$ or the ration shop (p) and the price at which the household can sell its home production on the market z. Formally, using $U'(c) = \beta u'(c)$ and $\theta = \lambda/\beta$ where $\lambda = \lambda(y)$ the marginal value of income when the household faces price $z + t$, as defined in Section 3:

$$\begin{aligned} c_m \quad & = 0 && \text{if } t_2 < z \\ & = 0 && \text{if } t_2 \geq z, p < z \text{ and } \theta \leq \tfrac{u'(\bar{c})}{p(1+m(p,q))} \\ & = c_m(z,p) < q && \text{where } u'(c_m(z,p)) = \tfrac{z(1+m(p,q))}{\theta} \text{ if } t_2 \geq z, p \geq z \text{ if } \theta \leq \tfrac{u'(q)}{p(1+m(p,q))} \\ & = q && \text{if } t_2 \geq z, p \geq z \text{ and } \theta > u'(q)/p(1 + m(p,q)) \end{aligned} \tag{20}$$

where $m(p, q)$ is defined below.

Using c_m as defined above the three solution possibilities to the consumer's maximization problem are:[31]

(i) *Low demand for the good:* $c = c(p) < \bar{c}$ *if* $\theta < \frac{p(1+m(p,q))}{u'(c_m+\bar{c})}$.
The term $m(p, q) = s(p - z - t)(r - \eta)$ captures the change in the marginal utility of income when the household faces the ration price p instead of the net of linear tax market price $z + t_2$. In this case the first order condition yields the solution $c(p) < \bar{c}$ where $u'(c_m + c_p) = \frac{(1+m(p,q))p}{\theta}$. There will be more households in this category when the market price of the good is low if the good is normal. Applying Roy's identity yields the derivative

[31] All the results in this section are obtained by solving the problem for cases with $c \leq \bar{c}$, $c \geq \bar{c}$ and considering separately cases in which these constraints are binding and non-binding.

$$\frac{\partial v}{\partial p} = -\lambda(1+m(p,q))c(p) \tag{21}$$

(ii) *Intermediate demand for the good:* $c = \bar{c}$ *if* $\frac{p(1+m(p,q))}{u'(c_m+\bar{c})} \leq \theta \leq \frac{(z+t_2)(1+m(t_2,q))}{u'(c_m+\bar{c})}$.
The term $m(t_2, q) = \tilde{s}(t_2 - t)(r - \eta) - r\frac{(z+t_2-p)\bar{c}}{R}$ captures the change in the marginal utility of income when the household faces marginal price $z + t_2$ instead of $z + t$ and receives an implicit transfer equal to the subsidy times the quota $(z + t_2 - p)\bar{c}$. Consumption is given by $c = \bar{c}$. We have

$$\frac{\partial v}{\partial p} = -\lambda(1+m(p,q))\bar{c}\ ;\ \frac{\partial v}{\partial \bar{c}} = U'(\bar{c}+c_m) - \lambda(1+m(p,q)) < p \geq 0 \tag{22}$$

where the inequality follows from the fact that households are effectively constrained at $\bar{c}$: they would like to buy $c \geq \bar{c}$ at price p and $c \leq \bar{c}$ at any price above or equal to $z_j + t_2$. A small relaxation of the constraint increases utility by more than the price of c below $\bar{c}$ but by less than the (marginal) price of c above $\bar{c}$: $\lambda(1+m(t_2))(z+t_2) \geq U'(\bar{c}+c_m) \geq p\lambda(1+m(p))$.

(iii) *High demand for the good:* $c = c(t_2) > \bar{c}$ *if* $\theta > \frac{(z+t_2)(1+m(t_2,q))}{u'(c_m+\bar{c})}$.

Here $\frac{(1+m(t_2,q))(z+t_2)}{\theta} = u'(c_m + c_j)$. We have

$$\frac{\partial v}{\partial t_2} = -\lambda(1+m(t_2,q))(t_2+z-p)\bar{c})(c-\bar{c})\ ;\ \frac{\partial v}{\partial \bar{c}} = \lambda(1+m(t_2,q))(z+t_2-p)\ ;\ \frac{\partial v}{\partial p} = -\lambda(1+m(t_2,q))\bar{c}. \tag{23}$$

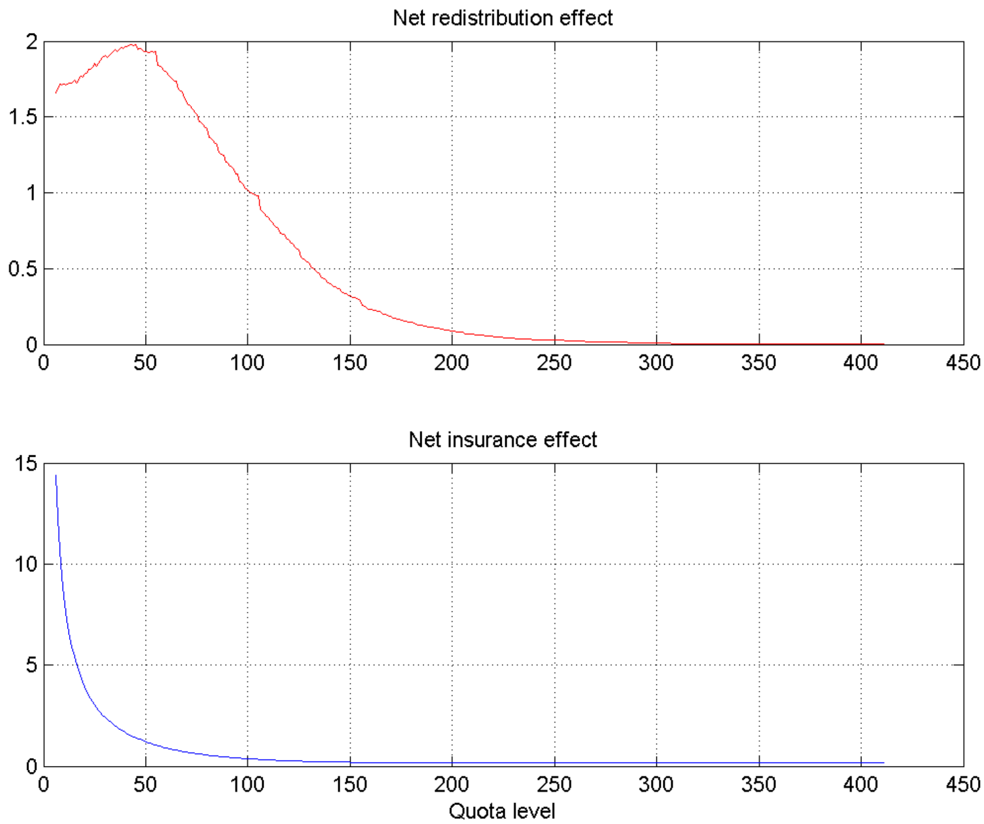
A.1.2 Model with costly resale

Consider the case where households can re-sell commodities that they purchase in the ration shops at the market price at a cost $f(\bar{c}-c)$ with $f(.)$ increasing and convex $\bar{c}-c$ the amount that is available for resale. Households in categories (ii) and (iii) above will never find it optimal to re-sell their quotas as their preferred level of purchase is higher than the quota. Households in category (i) can be further divided into three groups. Define $\hat{c}$ as the consumption level such that the marginal price of extra consumption is equal to its marginal benefit $\theta(1 + m(p))(q + t_2 - f'(\bar{c} - \hat{c})) = u'(\hat{c} + c_m)$. Households with with $f'(0) > z + t_2 - p$ have high resale costs and will only purchase what they consume, $c = c(p)$ as defined above. Those with $f'(0) < z + t_2 - p < f'(\bar{c} - \hat{c})$ will purchase less than their quota from the ration shop and re-sell part of it as the marginal cost of full resale is too high. Finally households with $z + t_2 - p > f'(\bar{c} - \hat{c})$ will purchase their entire quota amount and re-sell what they do not consume.

The introduction of resale adds an extra mechanical welfare impact of introducing a higher tax rate above the quota in the marginal redistribution effect $\gamma(\bar{c})$: households which re-sell part of their quota will consume at a price p but re-sell at price $z + t_2$ and hence gain from higher tax rates (income effect). This goes in the same direction as the mechanical effect discussed in the text: a ration shop schedule transfers resources from households purchasing more than the quota to households purchasing less than the quota. It also adds a behavioral effect which is a function of the elasticity of resale to the tax inclusive market price: as this price increases households in group i) will want to re-sell more and hence will purchase more from the ration shops, re-enforcing the price elasticity effect discussed in the text. Allowing for costly resale therefore reinforces the conclusions reached in the model without resale. It introduces a new parameter - the elasticity of resale with respect to price, a function of the curvature of $f(.)$ - and a new variable at the household level, amounts resold on the market. Neither of those are observable in the data used.

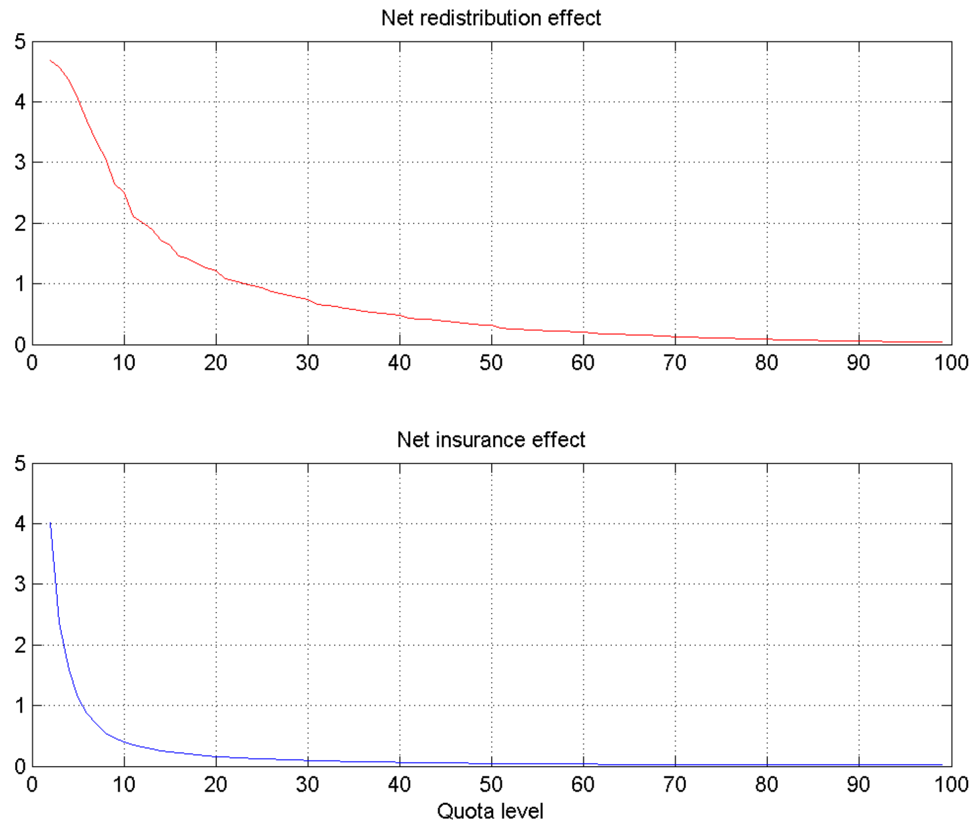
A.2 Additional tables and figures

Figure 10: Net redistribution and insurance effects by quota level - rice



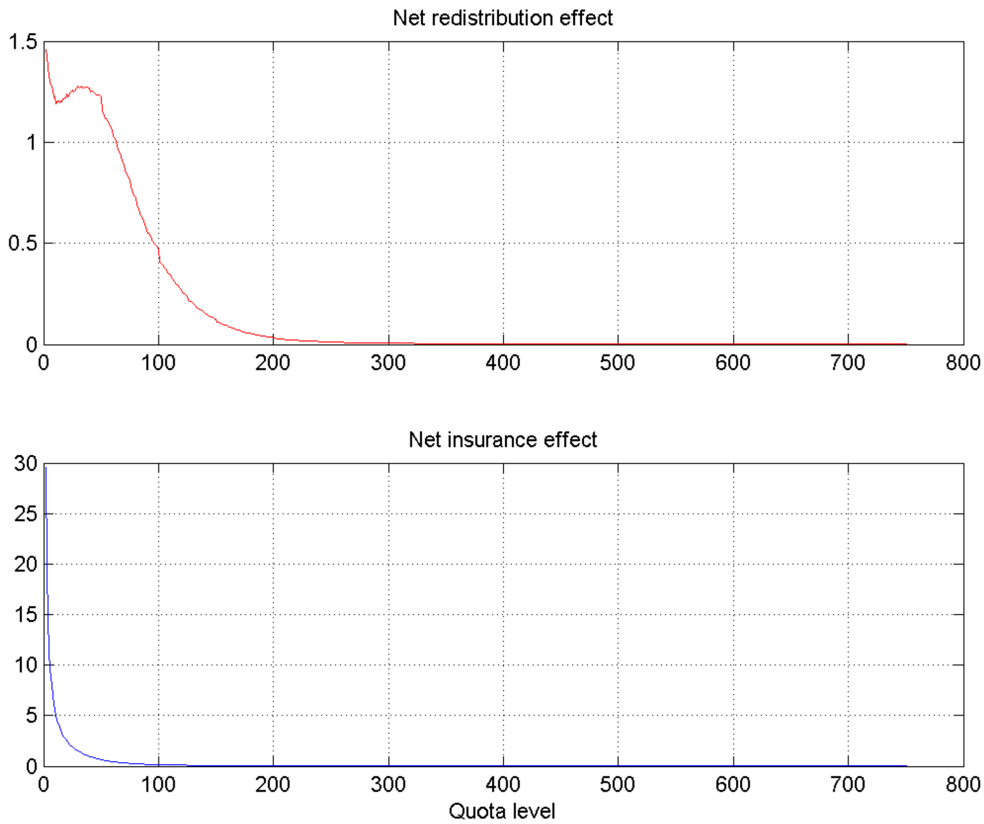
Net redistribution (in red) and insurance (in blue) effects of introducing a ration shop schedule for each good as a function of the quota level.

Figure 11: Net redistribution and insurance effects by quota level - kerosene



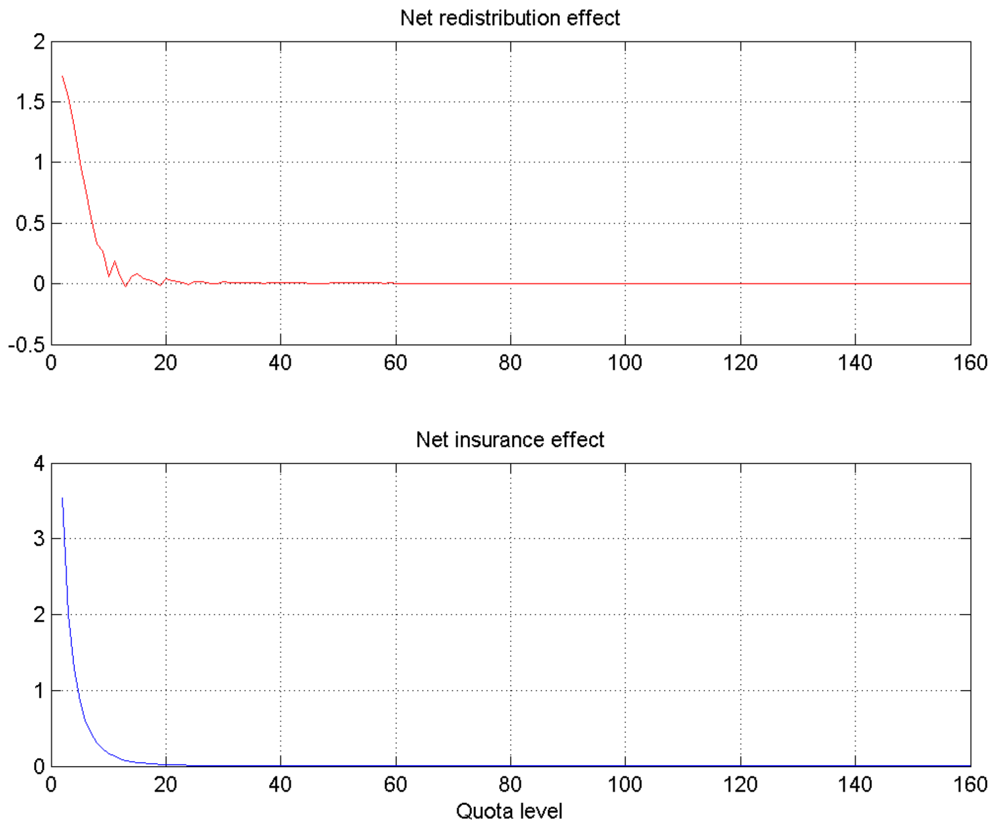
Net redistribution (in red) and insurance (in blue) effects of introducing a ration shop schedule for each good as a function of the quota level.

Figure 12: Net redistribution and insurance effects by quota level - wheat



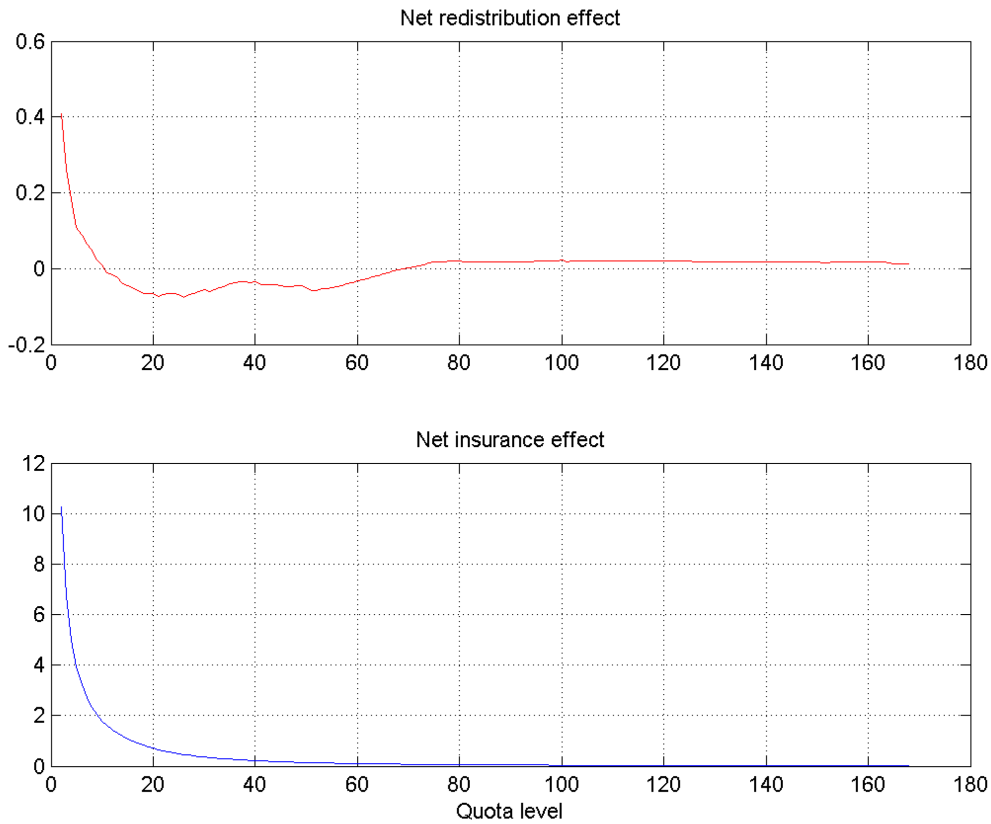
Net redistribution (in red) and insurance (in blue) effects of introducing a ration shop schedule for each good as a function of the quota level.

Figure 13: Net redistribution and insurance effects by quota level - sugar



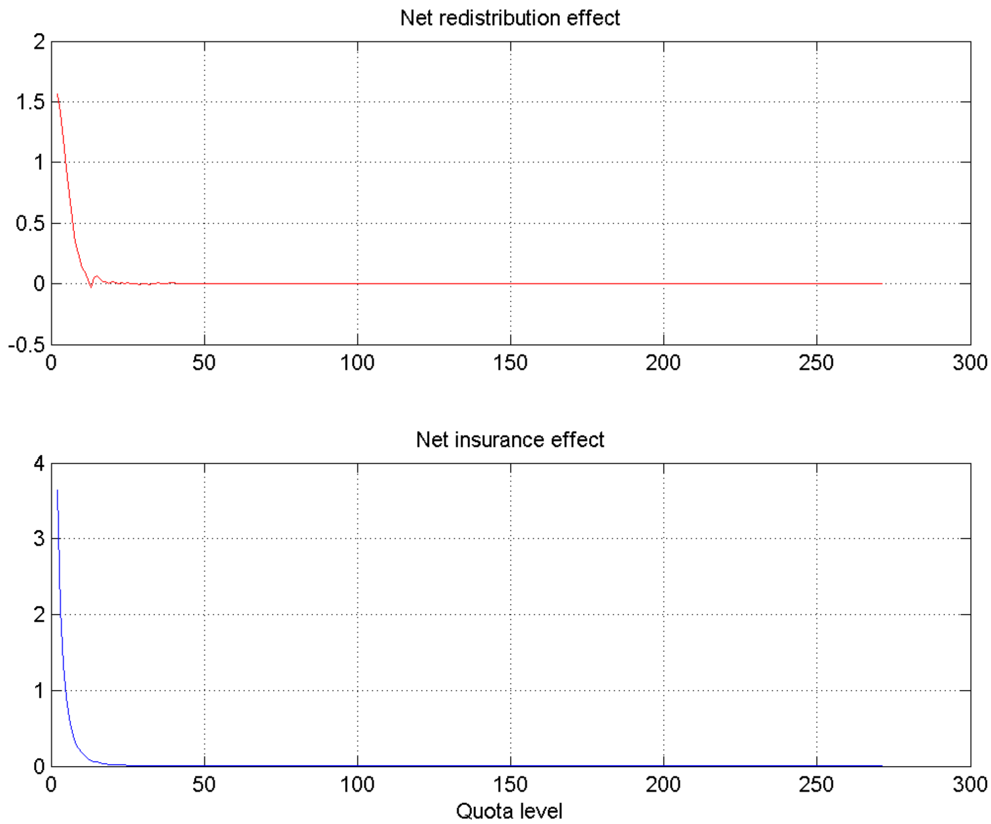
Net redistribution (in red) and insurance (in blue) effects of introducing a ration shop schedule for each good as a function of the quota level.

Figure 14: Net redistribution and insurance effects by quota level - coarse cereals



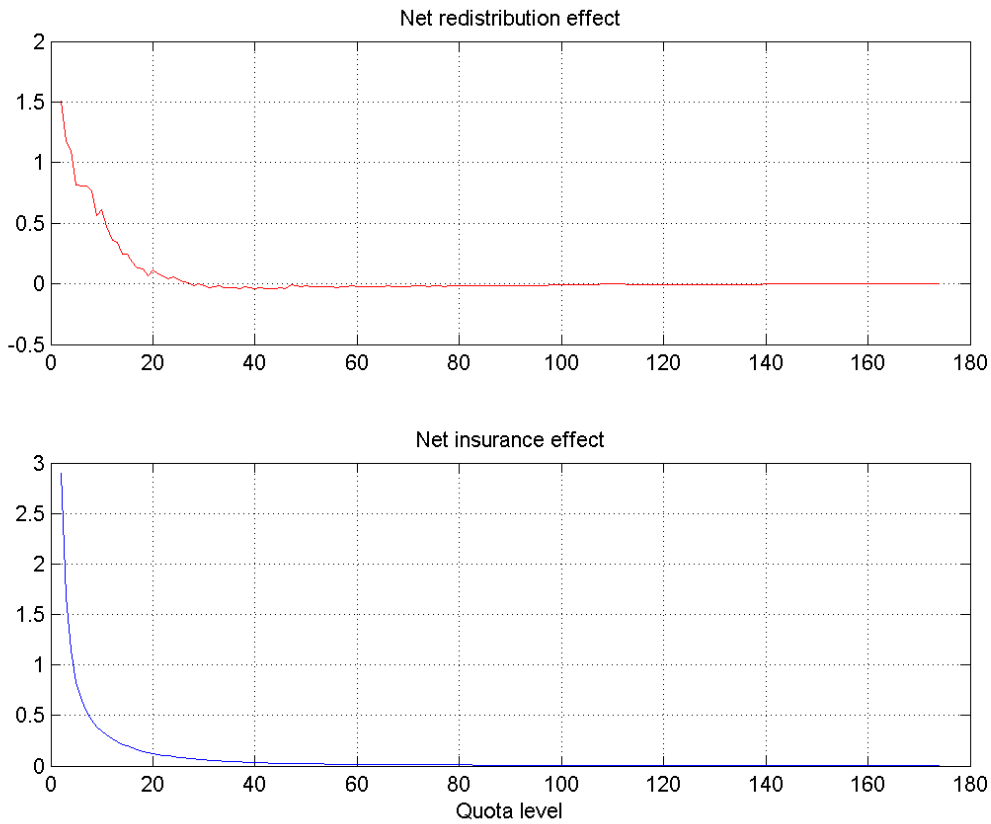
Net redistribution (in red) and insurance (in blue) effects of introducing a ration shop schedule for each good as a function of the quota level.

Figure 15: Net redistribution and insurance effects by quota level - pulses



Net redistribution (in red) and insurance (in blue) effects of introducing a ration shop schedule for each good as a function of the quota level.

Figure 16: Net redistribution and insurance effects by quota level - meat and fish



Net redistribution (in red) and insurance (in blue) effects of introducing a ration shop schedule for each good as a function of the quota level.

Table 5: Net insurance and redistribution benefits

	Rice	Kerosene	Wheat	Sugar	Cereals	Pulses	Meat
Baseline (R)	0.375	0.253	0.094	-0.245	-0.183	-0.147	-0.225
Baseline (I)	0.637	0.172	0.325	0.057	0.244	0.037	0.071
Estimates from K2011 (R)	0.236	0.149	0.024	-0.294	-0.564	-0.175	-0.259
Estimates from K2011 (I)	0.679	0.168	0.318	0.053	0.326	0.035	0.069
Estimates from D1994 (R)	0.578	0.393	0.190	-0.174	-0.044	-0.105	-0.142
Estimates from D1994 (I)	0.534	0.177	0.322	0.059	0.249	0.039	0.075
Welfarist (R)	0.679	1.077	0.196	-0.151	0.026	-0.095	-0.089
Welfarist (I)	0.634	0.186	0.344	0.050	0.257	0.030	0.051
Budget neutral (R)	0.285	0.192	0.053	-0.274	-0.478	-0.164	-0.261
Budget neutral (I)	0.626	0.170	0.321	0.055	0.330	0.035	0.069
Budget surplus (R)	0.098	0.007	-0.146	-0.430	-0.701	-0.307	-0.431
Budget surplus (I)	0.651	0.165	0.313	0.050	0.322	0.031	0.063
Low risk aversion (R)	0.375	0.253	0.094	-0.245	-0.183	-0.147	-0.225
Low risk aversion (I)	0.587	0.166	0.303	0.056	0.238	0.035	0.067
Urban only (R)	0.136	0.579	0.098	-0.193	-0.214	-0.105	-0.198
Urban only (I)	0.443	0.357	0.420	0.061	0.241	0.045	0.219
Rural only (R)	1.555	-0.498	-0.101	-2.551	-2.959	-0.776	-3.247
Rural only (I)	0.778	0.109	0.566	-0.002	0.358	0.041	-0.009

Each cell is the net redistribution (R) or insurance (I) effect per unit of revenue spent of introducing a ration shop schedule for each good considered in the columns. The first two lines are the baseline estimates, the second two use demand parameters from Kumar *et al.* (2011), the next two demand parameters from Deaton and Subramanian (1994), the next two are obtained using a welfarist social welfare function, the next two assume that the exogenous revenue requirement is 0, the following two that it is 0.6% of total consumption of the seven good, the following two consider the case when relative risk aversion of the non-poor is set to 1, and finally the last four lines present results for urban and rural households separately. See the text for a description of the data and parameters used and the definition of R and I.

Table 6: Results by state

	Rice	Kerosene	Wheat	Sugar	Cereals	Pulses	Meat
Andhra Pradesh (R)	0.308	-0.188	-0.450	-0.866	0.003	-0.803	-0.228
Andhra Pradesh (I)	0.948	0.085	0.104	0.106	0.292	0.149	0.041
Bihar (R)	0.441	-0.767	0.498	-1.124	-1.241	-1.015	-0.827
Bihar (I)	1.058	0.160	1.259	0.068	0.191	0.183	0.029
Gujarat (R)	-0.005	0.702	-0.124	-0.595	0.429	-0.322	-0.558
Gujarat (I)	0.424	0.433	0.591	0.184	0.498	0.122	0.081
Haryana (R)	-0.133	-0.224	0.185	-0.228	-0.222	-0.619	-0.595
Haryana (I)	0.099	0.103	0.966	0.266	0.175	0.190	0.187
Karnataka (R)	0.339	0.181	-0.086	-0.542	0.625	-1.126	-0.381
Karnataka (I)	0.649	0.178	0.347	0.163	0.474	0.165	0.080
Kerala (R)	0.201	-0.366	-0.264	-0.576	-5.384	-1.023	-0.053
Kerala (I)	0.922	0.053	0.207	0.158	1.011	0.511	0.374
Madhya Pradesh (R)	0.356	0.028	0.363	-0.273	1.299	-0.810	-0.915
Madhya Pradesh (I)	0.701	0.159	1.134	0.073	0.720	0.218	0.044
Maharashtra (R)	-0.012	0.241	0.056	-0.419	-0.019	-0.222	-0.435
Maharashtra (I)	0.402	0.276	0.445	0.184	0.366	0.077	0.071
Orissa (R)	0.631	-0.072	-1.861	-1.186	-0.261	-2.077	-1.563
Orissa (I)	1.872	0.154	0.233	0.072	0.478	0.115	0.084
Punjab (R)	-0.100	0.129	0.110	-0.230	-0.628	-0.208	-0.693
Punjab (I)	0.143	0.429	0.672	0.252	0.142	0.083	0.123
Rajasthan (R)	-0.395	-0.307	0.168	-0.286	0.310	-0.122	-0.524
Rajasthan (I)	0.059	0.154	0.777	0.102	0.563	0.025	0.040
Tamil Nadu (R)	0.321	0.092	-0.208	-0.963	-0.299	-1.245	-0.391
Tamil Nadu (I)	1.131	0.246	0.105	0.157	0.143	0.450	0.079
Uttar Pradesh (R)	0.291	-0.234	0.364	-0.251	-0.933	-0.474	-0.723
Uttar Pradesh (I)	0.554	0.098	0.859	0.062	0.162	0.079	0.094
West Bengal (R)	0.860	0.157	0.009	-0.828	-0.159	-0.803	-0.263
West Bengal (I)	1.121	0.176	0.467	0.072	0.128	0.062	0.122
Delhi (R)	-0.070	0.815	0.103	-0.354	-3.574	-0.566	-0.852
Delhi (I)	0.319	0.960	0.494	0.145	0.245	0.254	0.073
Jharkand (R)	0.701	-0.135	-0.443	-1.662	1.725	-1.020	-0.453
Jharkand (I)	1.036	0.179	0.804	0.110	0.215	0.142	0.033
Chhattisgarh (R)	0.652	-0.100	-0.768	-0.390	-2.504	-1.349	-1.782
Chhattisgarh (I)	1.443	0.115	0.378	0.068	0.233	0.171	0.053
Uttarkhand (R)	0.156	-1.007	1.890	-0.839	2.766	0.926	-1.121
Uttarkhand (I)	0.481	0.158	0.874	0.432	0.432	0.128	0.053

Each cell is the net redistribution (R) or insurance (I) effect per unit of revenue spent of introducing a ration shop schedule for each good considered in the columns and state considered in the rows. See the text for a description of the data and parameters used and the definition of R and I.